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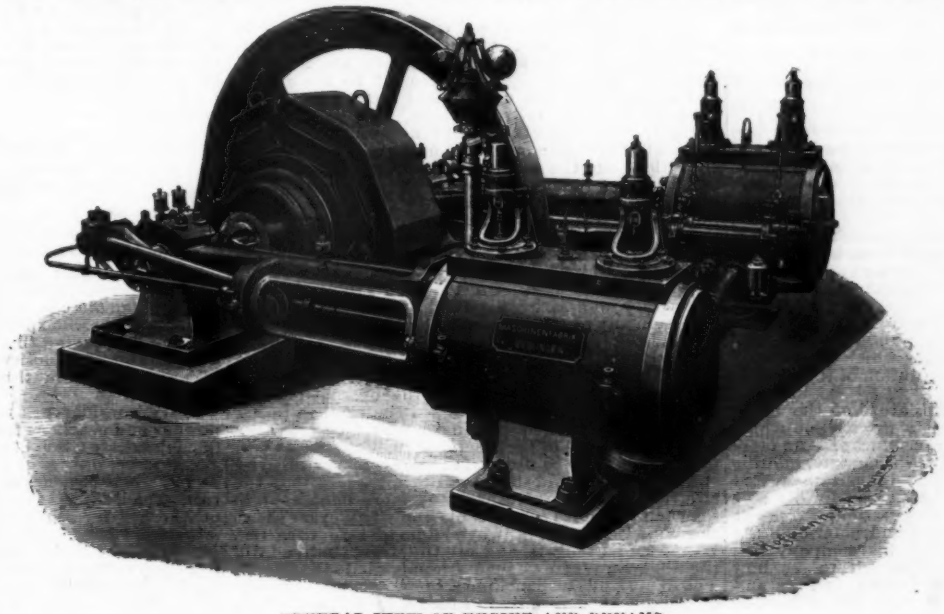
COMBINED DYNAMO AND ENGINE.

THE Maschinenfabrik Esslingen show several interesting dynamos and engines. We illustrate a double-cylinder horizontal engine driving a multipolar drum machine. The engine is designed to indicate 100 h. p. under 120 lb. steam pressure at 100 revolutions per minute. The engine is arranged to take as little room as possible, and at the same time to be simple and durable, and to give a high efficiency. This engine and dynamo give 26 watt hours per pound of steam, or, with a condenser, 32 watt hours.

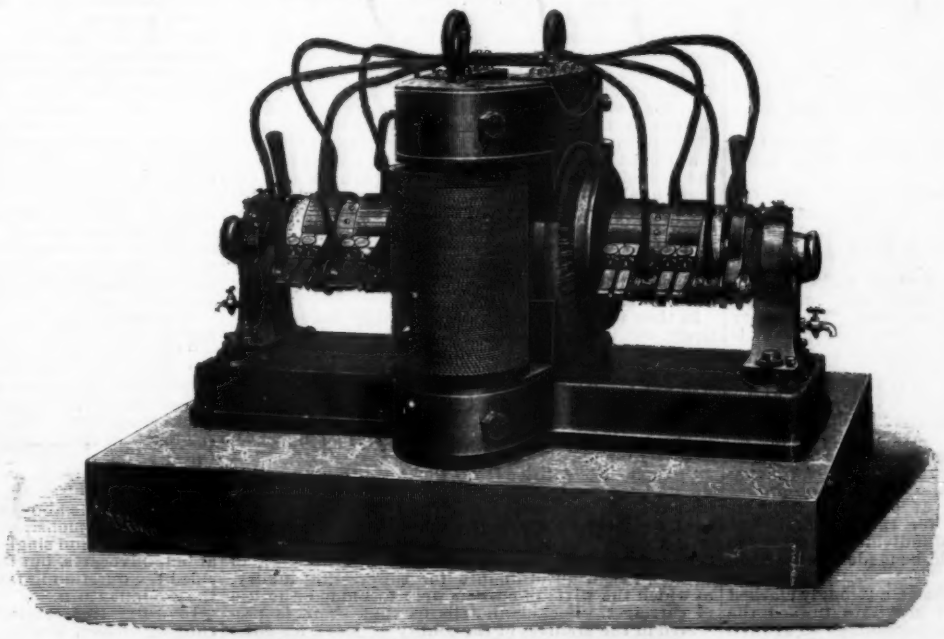
The dynamo has eight poles, and the armature is direct driven, being mounted on the engine shaft. It has only two brushes, and is wound to give a high pressure for coupling on a five-wire system of distribution. The terminals of the machine are connected to the outer wires of the five-wire system, and the intermediate wires, as well as the outer, are joined up to a sort of regulating dynamotor. This is an ordinary dynamotor, with four armature circuits instead of two. If the four circuits fed by the five-wire system are all taking equal currents, this machine runs round, taking a minute current from each circuit to keep it revolving. If one of the four circuits has more lamps on than the others, its pressure falls a very little. The dynamotor then takes power from the other three circuits and gives it back to the circuit having the heavy load. We believe this method of working multiple-wire systems is due to Professor Elihu Thomson.

The dynamotor is a comparatively small machine, as it need only be large enough to take or supply the balance of power needed in the circuits. If it were not employed, it would be necessary either to have four dynamos to feed the system or to have one machine with four armature circuits and five sets of brushes, each armature circuit being able to give the full load that might be needed on any one of the four circuits of the five-wire system. This interesting machine we also illustrate. These machines supply a 50 h. p. electromotor for pumping water for the Exhibition and other motors in the workshop building, and do a quantity of lighting as well. The small cut shows a curious ½-horse power motor.

In connection with the exhibit of this firm we must mention a most complete railway electric van. This is about the size of a large cattle truck, but it contains a small and compact locomotive boiler, and a Westinghouse engine driving an Esslingen dynamo. The wagon carries cables, six arc lamps, and everything needed for giving light to a breakdown gang making repairs at night or in a tunnel, or for lighting up part of a line for any purpose—for instance, during rebuilding or repairs, or during busy seasons when night work is necessary.—*Industries.*



GENERAL VIEW OF ENGINE AND DYNAMO.



DYNAMOTOR, WITH FOUR ARMATURE CIRCUITS.

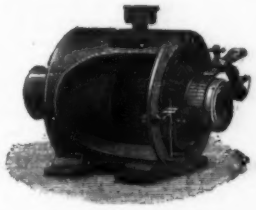
FRANKFORT ELECTRICAL EXHIBITION—THE MASCHINENFABRIK ESSLINGEN'S EXHIBIT.

DEVELOPMENT OF ELECTRIC RAILWAYS.*

By EUGENE GRIFFIN.

THE first recorded description of the electric car is found in the fourth verse of the second chapter of Nahum: "The chariots shall rage in the streets; they shall jostle one against another in the broad ways; they shall seem like torches; they shall run like the lightnings."

Notwithstanding this early mention it was not until 1888 that the electric railway became a practical commercial success. I fix the date at 1888, as it was in that year that Bentley & Knight opened the Allegheny City road to regular traffic; that the Sprague company equipped the Richmond road, and the Thomson-Houston company installed the Eckington & Soldiers' Home road in Washington. It was in 1888 that railway officials began to realize the possibilities of this new tractive force; that the great West End System



of Boston adopted electricity to the exclusion of cable, and that orders began to flow in upon the electric companies for street car motors to such an extent as to soon make the manufacture of such motors one of the leading branches of the electric industry.

Previous to 1888 electric motors had been used on several roads. Some of these roads were doing well and have been prosperous since; but to the public these were experiments on a comparatively small scale, and did little to inspire general confidence. The early inventors found it difficult to secure adequate financial backing; orders were few and business unprofitable. The stronger companies which took up the work in 1888 had the organizations and capital necessary to achieve success.

The pioneers who devoted their brains and frequently their purses to this work previous to 1888 are deserving of all credit. It was their misfortune, not their fault, that their ideas were not developed and worked commercially. It is difficult for one man to combine the qualities of inventor, manager, superintendent, seller, expert and financier, and yet this is what Van Depoele, Daft, Bentley & Knight and others had to attempt. The record of their efforts is an interesting one, but the chronological record of electric traction has been so frequently given that it would be a waste of your time to repeat it again.

There are, however, one or two of the early trials that are specially worthy of consideration, not only because of what was actually accomplished, but principally on account of their bearing on later developments. On July 27, 1884, an electric car was running scheduled trips over a mile of track of the East Cleveland Street Railway Company, in Cleveland, O. This was the first electric car in regular operation on a street railway track in the United States. The motor was placed between the wheels and supported from the car body, and geared to the axles by belts of spring wire cables. The current was conveyed to the car by the conductor supported on insulators in a small wooden conduit, and connection made with the conductors by means of a plow extending through the slot to the conduit. This was the initial installation of the Bentley & Knight system. Mr. Bentley has a photograph of the car in his office in Boston.

The road was given up in 1885, and the Bentley-Knight works transferred to Providence, R. I. After various experiments the road in Allegheny City was begun in the summer of 1887. The cars were started during the winter of 1887–88, although the road was not formally opened to traffic until February, 1888. Four cars were furnished to this road which, I believe, are still running. On the lower end of the road was a mile of double track conduit which was continued by an overhead system of about five miles. The conduit was on a long grade of about 12 per cent. Over-running trolleys were used with the overhead system. The conduit was in operation for two years or more, but now has been taken up and replaced by the overhead system.

As early as 1874, while C. J. Van Depoele was engaged in Detroit, experimenting with electric motors, generators, etc., it occurred to him that trains of cars, and even ordinary street cars, could be run by electricity. This was demonstrated to the satisfaction of his associates in various ways, but no public exhibition was made until 1883. When the Chicago elevated railway was under consideration, it was proposed to demonstrate the feasibility of utilizing electricity as a motive power. A track 400 feet in length was built, with a five per cent. grade in the center. One car was equipped with a three horse-power motor and ran for several weeks with considerable success, carrying crowds of people. This was in February, 1883. In the same year an elevated railway car was operated electrically at the Chicago Inter-State Fair. The car was suspended from the truck instead of being mounted on it; and was in operation during the entire exposition—some fifty days.

*A paper read before the National Electric Light Association, Montreal, 1891. Report of the *Electrical World.*

During the Toronto Annual Exhibition in 1884, an electric railway some 3,000 feet long was operated from the entrance to the grounds to the main building. This was a conduit road, and the wires carried a potential of over 1,000 volts without accident. A 30 horse-power electric locomotive was used, hauling trains of cars.

The Van Depoele company subsequently equipped roads at Minneapolis, Minn.; Montgomery, Ala.; Detroit, Mich.; Windsor, Ont.; Appleton, Wis.; Port Huron, Mich.; Scranton, Pa.; Lima, O.; Binghamton, N. Y.; Ansonia, Conn.; Dayton, O.; Jamaicia, N. Y.; St. Catherines, Ont., and elsewhere, many of which are still in operation.

In the fall of 1887 Frank J. Sprague contracted for the electrical equipment of the Union Passenger Railway at Richmond, Va. This was an important road in a large city, and Mr. Sprague's undertaking was the most ambitious effort in this direction up to that date. It is worthy of note that Sprague's original intention was to use motors with but one reduction, but he was forced to abandon this idea, as none of the electrical companies of that date were able to produce single reduction motors. The motors used at first were too light for the work, the copper brushes scored the commutators badly and were rapidly consumed. Nevertheless, Mr. Sprague persevered despite all obstacles, and in 1888 the road was running with so much success that it was one of the object lessons which induced Henry M. Whitney and his brother directors of the West End Street Railway of Boston to adopt electricity as a motive power when they were already far advanced in the plans for cabling their system.

As nearly as now can be ascertained, the following electric roads were actually in operation on January 1, 1888:

Roads.		Location.	Miles.	No. of motor cars.
Union Pass. Ry. Co.	Daft	Baltimore, Md.	2.00	3
Windsor Elect. Ry.	Van Depoele opp.	Detroit, Mich.	1.25	3
Appleton "	"	Appleton, Wis.	5.50	5
Port Huron "	"	Port Huron, Mich.	2.75	4
Highland Park	Fisher	Detroit, Mich.	3.25	4
Scranton Suburban road	Van Depoele	Scranton, Pa.	5.00	12
Los Angeles Elect. Ry. Co	Daft	Los Angeles, Cal.	5.00	6
Lima Street Ry. and Motor Power Co.	Van Depoele	Lima, Ohio	4.00	8
Columbus Consolidated Street Ry.	Short	Columbus, Ohio.	1.00	2
St. Catherines Street Ry. Co.	Van Depoele	St. Catherines, Ont.	7.00	12
Seashore Elect. Ry. Co.	Daft	Asbury Park, N. J.	4.00	18
San Diego Street Ry. Co.	Henry	San Diego, Cal.	3.00	9
E. Harrisburg Pass. Ry. Co.	Sprague	Harrisburg, Pa.	4.50	10

A total of 13 roads, 48.25 miles of track and 95 cars.

On July 1, 1891, there were 354 roads in actual operation, with 2,893 miles of track equipped electrically, and 4,513 motor cars. Such has been the growth of three and a half years.

This development has been marvelous and unprecedented. Referring to it, General Francis A. Walker said to me, not long since, that it seemed as though at least thirty years' normal development has been crowded into three years.

It has indeed been a fruithful period, and the progress has been so rapid that the public are just beginning to appreciate the benefits which science has conferred upon them by the adaptation of the electric motor to street car propulsion.

During the past spring the legislature of the State of Massachusetts was considering a proposition which practically amounted to the imposition of new taxes upon the West End Street Railway Company, and the abrogation or virtual annulment of certain vested rights which the company might claim. In his able and vigorous defense of his corporation, President Whitney was forced to investigate and determine the true relations which exist between his company and the public, and he was surprised himself to see how closely the welfare of the city of Boston and its surrounding suburbs was identified with the welfare of its street transportation system.

He at once entered upon a "campaign of education," and his speeches in Sommerville, Roxbury, Dorchester and elsewhere (several of which have been published in pamphlet form) are masterly, impressive, straightforward and convincing presentations of the close relations which exist between the rapid transit systems and the health, wealth, morality and prosperity of our large cities.

I commend these speeches to the consideration of you all. I have not hesitated to draw from them largely myself.

I consider this growing realization of the true position which transportation companies occupy in respect to the public as one of the most important of recent developments, and it may be well to give it some consideration.

The officers and directors of a street railway company are *quasi* public officers with most important and serious duties devolving upon them. Their duty to their stockholders is to see that the company is economically and efficiently administered so as to produce a fair return upon the capital invested. Their duty toward the public is to see that the best possible transportation facilities are afforded, having in view "the greatest good of the greatest number." This broad statement of their public duty is unquestionably true, and yet the failure to appreciate this axiom is the most fertile source of adverse criticism of railway management. The critic almost invariably argues from a personal standpoint. If he would only remember that the road is run for the benefit of the masses and not for his personal individual benefit, the lives of general managers would be made less burdensome.

The last census has clearly shown a strongly marked tendency of our population to gravitate toward the large cities. In every State the percentage of growth in cities is far greater than in towns and villages. Such condensation of population means an increase of the tenement house system in contradistinction to the cottage system, a crowding of people beneath each roof, an increase in vice, immorality, misery, crime and the death rate. How is it to be avoided? The laborer must live near his work, near in time and near in money. He can spare but a fraction of his time, but a fraction of his day's wages, in going to and from his work. If the zone fare system exists as in Europe, the area within which he can live is limited by this consideration. Two cents per mile might restrict him to a radius of 2½ miles (5 cents). If the single fare system prevails as in this country, time is practically the only restriction. Let us assume that he can allow thirty minutes morning and evening for his car ride, paying five cents for each ride. At the rate of six miles per hour, fast for horses, he has a radius of three miles and an area of 28¼ square miles within which to select a home. At the rate of nine miles per hour, slow for electricity, he has a radius of four and a half miles and an area of 63½ square miles within which to select a home. This example suffices to illustrate the point. An increase of only three miles per hour in rapidity of transit doubles the available residence area without increasing the time or expense of the laborer in going to and from his work.

The steam road, the elevated road, the underground road and the cable, each and all afford rapid transit; but their application is restricted within very narrow limits because of their great cost, while the electric roads can be profitably extended in all directions.

The great advantage of increasing the available residence area, of encouraging the cottage system and discouraging the tenement system, will be readily conceded by all. The health and morality of a great city are universally proportional to the number of people beneath each roof. The electric railway is one of the great moral agents of the nineteenth century.

The experience of the past three years has settled many disputed questions, resolved many doubts, systematized methods and improved construction.

A variety of styles, systems and methods were used prior to 1888. We had storage batteries, conduits and overhead wires; single trolley and double trolley wires, over-running trolleys and under-running trolleys.

Storage batteries have made little progress. They have nowhere scored a pronounced success, and have been abandoned on nearly every road. They are but little considered in the field of electric traction, except in reference to future possibilities.

The very few conduits built have disappeared and have been replaced with overhead wires. The overhead wire is now generally recognized as the only practical method of conveying electricity from the generator to the car motor.

The objections to overhead wires have been, and in many places still are, very strong; but actual experience has shown that the objections are not well founded. Wires are not an ornament to the street, and objections on this ground will always exist; but lamp posts, signs, railway tracks, and many other similarly useful objects are not ornaments. Overhead wires will never be condemned on this ground alone. Objections on the score of unsightliness become of less and less importance each year as the methods of construction are improved and the public appreciate more fully the benefits of electric motive power.

One of the early apprehensions in reference to the use of overhead wires was the possible danger to life from the current used. On this point I think the public are now well satisfied. While there are few employes on any of the roads now in operation who have not had the full shock of 500 volts repeatedly, there is not a single instance of any of the patrons of these roads who have been killed or even seriously injured by the 500-volt current from the overhead wires. Electric cars will run over and kill the careless pedestrian or the drunken passenger who falls from the platform in front of the wheels as will the horse car, but no passenger or pedestrian has ever been killed by the trolley wire, and statistics do not show that the electric car is in any respect any more dangerous to life than the horse car or cable car. Last year (1890) the West End street railway system of Boston carried 114,853,081 passengers, and all the steam railroads of the whole State of Massachusetts only carried 98,843,712. The West End system killed 15 passengers and employes and the steam roads killed 325. Of the 15 fatal accidents on the West End system, five were attributable to electric cars and ten to horse cars. It is only fair to say that the narrow and crooked streets of Boston and the enormous traffic of the West End system are conditions peculiarly conducive to accidents.

The fear of the electric current is one born of ignorance, and time alone can overcome it.

In the year 1889 nine human beings were killed by the arc light wires in New York City (2,500 volts), and the authorities were roused to such a pitch of frenzy that the poles were chopped down and a large part of the city left in darkness. Yet, with perhaps one exception, all of the victims were employes of the lighting companies, and suffered because of failure to observe proper and well known precautions. In the same year twelve persons were asphyxiated by gas and over thirty were killed by signs and other objects falling on their heads as they walked peacefully along the streets.

In time we are able to estimate every danger relatively, but in the beginning unknown dangers, those to which we are not accustomed, are greatly exaggerated.

Ralph W. Pope, in a very interesting paper read before the Franklin Institute last year, gives some curious illustrations of this tendency to magnify unknown dangers and arrest the progress of improvement. I quote:

"In an article entitled 'How Our Ancestors Traveled,' we find the following pertinent observations on the subject:

"Carriages met with great opposition at their first introduction, and laws were made to suppress their use. As early as the year 1294, Philip the Fair, of France, issued an ordinance for suppressing luxury, in which the wives of citizens were forbidden the use of carriages. Beckmann tells us that there is preserved in the archives of the county of Mark an edict in which the feudal nobility and vassals are prohibited from using coaches under pain of incurring the punishment of felony. Duke John of Brunswick published an order in 1588 roundly rating his vassals for neglect of horsemanship and forbidding them to appear or travel in coaches. A few years after this the English Parliament took up the discussion of the subject; but on the 7th of November, 1601, the bill to restrain the excessive use of coaches within the realm of England was rejected. But the bitterness of antagonism to them did not cease with this legislative decision. In a pamphlet called the 'Great Concern of England Explained,' published 1673, the writer very gravely attempts to make out that the introduction of coaches was ruining the trade of the realm. Following is an example of his method of reasoning: 'Before coaches were set up, travelers rode on horseback, and men had boots, spurs, saddles, bridles, saddlecloths and good riding suits, coats and cloaks, stockings and hats, whereby the wool and leather of the kingdom were consumed. Besides, most gentlemen, when they traveled on horseback, used to ride with swords, belts, pistols, holsters, portmanteaus and hat cases, for which in these coaches they have little or no occasion. For when they rode on horseback, they rode in one suit and carried another to wear when they came to their journey's end; but in coaches they ride in a silk suit, silk stockings, beaver hats, etc., and carry no other with them. This is because they escape the wet and dirt, which upon horseback they cannot avoid; whereas, in two or three journeys on horseback these clothes and hats were wont to be spoiled; which done they were forced to have new very often, and that increased the consumption of manufacture.' In another part of his pamphlet the same writer puts the following query, evidently with the notion that it was a clincher: 'Is it for a man's health or business to be laid fast in four ways; to ride all day with strangers, oftentimes sick, diseased, ancient persons, or young children crying; all whose humors he is obliged to put up with, and crippled with their boxes and bundles?' As an additional objection against the introduction of coaches, the writer urges that they would discourage the breeding and lessen the value of horses.

"The following passage occurs in a protest against the construction of railways which is preserved in the archives of the Nuremberg Railway, at Furth, which was the first line constructed in Germany. It was drawn up by the Royal College of Bavarian Doctors:

"'Travel in carriages drawn by a locomotive ought to be forbidden in the interest of public health. The rapid movement cannot fail to produce among the passengers the mental affection known as *delirium furiotum*. Even if travelers are willing to incur this risk, the government should at least protect the public. A single glance at a locomotive passing rapidly is sufficient to cause the same cerebral derangement, consequently it is absolutely necessary to build a fence 10 feet in height on each side of the railway.'

"These were all European, however, so in order to assure you that these peculiar views were held in our country, the following protest from the good citizens of Philadelphia, in 1833, against the introduction of gas, will be of interest to you.

"'PHILADELPHIA, Nov. 28, 1833.

"'REMONSTRANCE AGAINST LIGHTING WITH GAS.

"'*To the Honorable the Select and Common Councils of the City of Philadelphia:*

"'GENTLEMEN: The subscribers beg leave to respectfully remonstrate against the plan now in action for *lighting the city with gas*, as they consider it a most offensive, inexpedient and dangerous mode of lighting. In saying this they are fully sustained by the accounts of explosions, loss of life and destruction of property where this mode of lighting has been adopted.

"'We consider gas to be as combustible as gunpowder and nearly as fatal in its acts; as regards the immense destruction of property, we believe that the vast number of fires in New York and other cities may be in a great measure ascribed to this mode of lighting. The leakage of pipes and carelessness of stopping off the gas furnish almost daily instances of its destructive effects. And when we consider that this *powerful and destructive agent* must necessarily be left open to the care and attention of youth and domestics and careless people, we only wonder that the consequences are not more *appalling*. It is also an uncertain light, sometimes suddenly disappearing and leaving streets and houses in total darkness.

"'The waters of the Delaware and Schuylkill, now considered the most pure and salubrious in the world, as many long voyages have fully tested, must soon, we fear, experience the deterioration which has reduced the water of the Thames to the present impure state, for no reservoir will be able to contain such fetid drains from such an establishment, and very soon the rivers must be their receptacle, to the destruction of the immense shoals of shad, herring and other fish with which they abound; the same cause must produce the same effect. Salmon, smelts and other fish formerly caught in vast quantities in the Thames have nearly all disappeared. The constant digging up of the streets, the circumstances of the gas pipes, which, at the intersection of each square, must come in contact with water pipes, are difficulties and evils which we would anxiously avoid.

"'In conclusion, we earnestly solicit that the *lighting our city with oil may be continued.*

"'And your petitioners, etc.

"'Signed by 1,200 of the leading citizens of Philadelphia, whose names are attached hereto, such as Horace Binney, Hartman Kuhn, Jacob Ridgway, Paul Beck, Henry Pratt, Benjamin Chew (on whose farm the battle of Germantown was fought) John Sargeant, Charles Wharton, Richard Willing, Edward Pennington, Robert Baux, Joshua Longstreath, Matthew Newkirk, and 1,200 others.

"'N. B.—The above are only part of the names, as many of the remonstrances have not yet come in.'"

The double and single trolley systems have each had ardent advocates, but three years' experience has decided the question in favor of the single trolley and the ground return.

In July, 1888, several roads were using the over-running trolley, and it was a question whether the over-running or under-running system was preferable. Three years have decided this question also, and practically all of the electric roads of to-day operate with

under-running trolleys. The "fish pole" of 1888 has been supplanted by the neat steel rod of 1891, and the "broomstick train" can no longer be spoken of with disrespect as regards outward appearances.

Three years have not passed without much litigation and already we have historical cases finally determined, which tend to fix the legal boundaries of the rights of electric railways. Some of these decisions are of great importance.

The telephone companies have quite naturally been ardent advocates of the double trolley, and, to avoid suffering from the induced currents of the single trolley, they have sought to induce the courts to compel railway companies to use metallic circuits. A recent decision of the Supreme Court of the State of Ohio is a fair statement of the present legal aspect of this question:

Single Trolley System vs. Double Trolley.

[Supreme Court of Ohio.]

SYLLABUS.

1. The dominant purpose for which streets in a municipality are dedicated and opened is to facilitate public travel and transportation, and in that view new and improved modes of conveyance by street railways are by law authorized to be constructed, and a franchise granted to a telephone company for constructing and operating its lines along and upon such streets is subordinate to the right of the public in the streets for the purpose of travel and transportation.

2. The fact that a telephone company acquired and entered upon the exercise of a franchise to erect and maintain its telephone poles and wires upon the streets of a city prior to the operation of an electric railway thereon will not give the telephone company, in the use of the streets, a right paramount to the easement of the public to adopt and use the best and most approved mode of travel thereon; and if the operation of the street railway by electricity as the motive power tends to disturb the working of the telephone system, the remedy of the telephone company will be to readjust its methods to meet the condition created by the introduction of *electromotive* power upon the street railway.

3. Where a telephone company, under authority derived from statute, places its poles and wires in the streets of a municipality, and, in order to make a complete electric circuit for the transmission of telephonic messages, uses the earth, or what is known as the "ground circuit," for a return current of electricity; and where an electric street railway afterward constructed upon the same streets is operated with the "single trolley overhead system," so called, of which the ground circuit is a constituent part, if the use of the ground circuit in the operation of the street railway interferes with telephone communication, the telephone company, as against the street railway, will not have a vested interest and exclusive right in and to the use of the ground circuit, as a part of the telephone system.

The telephone companies have been beaten in every case, and the fact has been definitely settled that railway companies may use a single overhead trolley wire and a ground return without infringing any rights of the telephone companies.

Many interesting legal questions have arisen in reference to line construction.

Objection was made by the summer residents of Newport to the construction of an overhead electric railway, and eminent counsel was employed to place every possible legal obstacle in the way. The case was carried to the Supreme Court of the State of Rhode Island for determination of some of the novel points involved, and one of these points was:

Are poles and wires an additional servitude upon the streets?

The court held:

"The fourth ground alleged is that, if the act of incorporation authorizes the use of electricity for the operation of said street railway, and the erection of the poles as ancillary thereto, it is unconstitutional and void, because it authorizes the imposition of additional servitude upon the streets without providing for any additional compensation to the owners of the fee of said streets. We think it is settled by the greater weight of decision that a railroad constructed in a street or highway, and operated by steam in the usual manner, imposes a new servitude, and entitles the owner of the fee to an additional compensation; but that a street railway operated by horse power, as such street railways are ordinarily operated, does not impose any new servitude, and does not entitle the owner of the fee to any additional compensation.

"The distinction is not often stated as a distinction between steam and horse railroads; but the distinction properly rests, not on any difference in motive power, but on the different effects produced by them respectively on the highways or streets which they occupy. A steam railway is held to impose a new servitude, not because it is operated by steam, but because it is so operated as to be incompatible with the use of the street in the other usual modes, or in other words, so as practically to exclude the usual modes of use.

"A steam railroad on a street, so operated as to be consistent with the use of the street in the usual modes, has been held not to impose a new servitude.

"It is not the motor but the kind of occupation, whether practically exclusive or not, which is the criterion.

"The only considerable privilege which the horse car has over other vehicles is that, being confined to its tracks, it cannot turn aside for other vehicles, while they are forced to turn aside for it; but this is an incidental matter, insufficient to make a horse railroad a new servitude.

"The street railway here complained of is operated neither by steam nor horse power, but by electricity. It does not appear, however, that it occupies the streets or highways any more exclusively than if it were operated by horse power.

"Reference has been made to cases which hold that telegraph or telephone poles and wires erected on streets or highways constitute an additional servitude, entitling the owners of the fee to an additional compensation, and from these cases it is argued that the railway here complained of is an additional servitude, by reason of the poles and wires which communicate its motive power. There are cases which hold as stated, and there are cases which hold otherwise, but assuming that telegraph and telephone poles and wires do create a new servitude, we do not think it follows that the poles and wires erected and used for the service of said street railway likewise create a new servitude. Telegraph and telephone poles and wires are not used to facilitate the use of the streets where they are erected for travel and transportation, or, if so, very indirectly so; whereas the poles and wires here in question are directly ancillary to the uses of the streets as such, in that they communicate the power by which the street cars are propelled."

In the purely technical field all obstacles have been overcome. Like Perry, "We have met the enemy and they are ours." The severe strain imposed by railway work on the generating plant has necessitated the development of new types of engines and the fluctuations of the dynamos have been prevented by compound winding and series coils. Self-regulating dynamos are now considered necessary in any well planned power plant.

I attended the exposition at Bremen, in North Germany, last summer, and had the pleasure of riding on an electric railway operated by two 80 horse-power Thomson-Houston dynamos. One dynamo was driven by a 70 horse-power Armington & Sims engine, and one by a 125 horse-power German engine. So closely did the small American engine regulate that no variation in potential could be observed under the most violent and sudden variations in load. Notwithstanding its greater power, the German engine was slow to respond and the variations in speed were marked. I was subsequently informed that a medal was awarded to the American engine, although it had not been entered as an exhibit.

This is indicative of the enterprising way in which the inventors and manufacturers of the United States have met the new conditions imposed by the adoption of electricity as a motive power.

The difficulties Mr. Sprague encountered in Richmond in using copper brushes have now been avoided by the introduction of the carbon brush, for which we are indebted to Mr. C. J. Van Depoele.

As early as 1883–84 Van Depoele used carbon brushes with his motors. When the Van Depoele Electric Manufacturing Company was purchased by the Thomson-Houston company in 1888, Van Depoele went to the Lynn factory of the latter company. Many did not then consider the carbon brush as practicable, and it was some time before Mr. Van Depoele had an opportunity to demonstrate its possibilities. When the time did come, its great value was so apparent that it was at once adopted for motor work and subsequently has been used exclusively with generators.

Since the general adoption of the present method of mounting the motors directly on the axles, double reduction motors have been used. The supposed necessity of high speed of revolution in the armature made this obligatory. In 1890 it was found practicable to make motors in which the armature revolved at a slower rate, and a single gear sufficed for the now greatly reduced reduct... From 10 and 12 to 1 with the old motor we come to 4½ to 1 w th the new motors. The gears are inclosed in boxes and run in oil, so that the noise has been reduced to a minimum, the offensive noise of the gears being practically eliminated. We have also gearless motors with no reduction and no gears.

Generator construction has kept pace with the improvements.

As larger stations have been built, generators have increased in size, and electrical companies are now producing 500 horse power dynamos as readily as the steam engine builders respond to similar demands.

We have learned what it costs to operate electric railways and the result is gratifying. In 1888 it was prophesied that while electric roads might make good showings so long as the apparatus was new and curiosity riding lasted, in a short time the machinery would begin to wear out and the roads would be swamped by the great repair bills. In reality we find the almost universal testimony is that the longer the road runs, the less is the cost of repairs. This is, of course, not due to the fact that the apparatus improves in quality with age, but the explanation is to be found in the very simple fact that as small defects are eliminated and the employes become more experienced and the organization is perfected, the apparatus is better cared for and injuries are prevented.

A very conspicuous example of this is the West End Street Railway, which has been under my own immediate observation.

In the contract between the Thomson-Houston Electric Company and the railway company it was provided that we should keep the overhead line and electrical apparatus on the cars in repair at a given price per car mile. There were many reasons which influenced us to make such a contract, but the chief reason was that this was the uncertain element in the operation of an electrical railway, and unless this uncertainty could be eliminated the West End would not make any contract. The cost of these repairs has steadily decreased, and on October 1 the West End Company avail themselves of their option and relieve us of this part of our contract, knowing there is now no uncertainty, and that they can do the work themselves for less money than they pay us.

Some months since President Whitney gave to the public the detailed figures showing the receipts and operating expenses of the West End road. These are of very great interest to all, and I give them in full for the purpose of drawing some conclusions from them:

THE ELECTRIC SYSTEM.

	April.	May.	June.	July.
Gross receipts	$134,321	$144,638	$153,988	$144,532
General expenses	8,193	7,790	7,465	6,955
Track and car expenses	47,447	45,448	39,690	43,891
Motive power	30,194	30,924	26,359	26,398
Total operating expenses	85,834	84,163	73,459	77,249
Net earnings	48,487	60,475	80,529	67,303
Miles run	394,459	376,321	360,567	377,191
Ratio of mileage	26·68	25·58	25·15	25·19
Per cent. operating expenses	63·06	58·18	47·70	53·44
Earnings per mile run	34·05	38·43	42·71	38·32
Expenses per mile run:				
Motive power	07·65	08·22	07·31	07·00
Car repairs	01·39	08·33	01·18	01·17
Damages	00·75	00·89	00·16	00·12
Conductors and drivers	07·33	07·36	07·25	06·92
Other expenses	04·63	04·36	04·47	05·37
Total expenses per mile run	21·75	22·36	20·37	20·48
Net earned per mile run	12·30	16·07	22·34	17·84

HORSE CAR SYSTEM.

Gross receipts	$344,306	$374,605	$395,555	$409,878
General expenses	22,514	22,682	22,217	20,657
Track and car expenses	126,693	127,903	125,308	135,954
Motive power	117,740	118,972	116,210	116,271
Total operating expenses	276,947	289,556	283,825	272,882
Net earnings	67,449	105,049	131,729	136,990
Miles run	1,083,887	1,094,693	1,073,718	1,120,377
Ratio mileage	73·32	74·42	74·85	74·81
Per cent. operating expenses	80·62	77·95	66·70	66·58
Earnings per mile run	31·77	34·22	36·85	36·58
Expenses per mile run:				
Motive power	10·86	10·86	10·83	10·38
Car repairs	00·93	00·60	00·61	00·61
Damages	00·78	00·37	00·15	00·06
Conductors and drivers	08·24	08·24	08·25	08·23
Other expenses	04·70	04·55	04·24	05·07
Total expenses per mile run	25·55	24·62	24·58	24·35
Net earned per mile run	06·22	09·60	12·27	12·23

THE ENTIRE SYSTEM.

Gross earnings	$478,717	$519,244	$549,543	$554,431
General expenses	30,707	30,473	29,683	27,481
Track and car expenses	184,141	173,344	165,027	179,613
Motive power	147,933	149,896	142,570	142,853
Total operating expenses	362,781	353,720	337,281	350,127
Net earnings	115,935	165,524	212,259	204,294
Miles run	1,478,316	1,171,004	1,433,785	1,497,568
Ratio mileage	100	100	100	100
Per cent. operating expenses	76·82	68·12	61·37	63·15
Earnings per mile run	32·39	35·29	38·33	37·03
Expenses per mile run:				
Motive power	10·01	10·19	09·94	09·53
Car repairs	01·05	00·79	00·76	00·75
Damages	00·77	00·50	00·15	00·07
Conductors and drivers	08·03	08·01	08·00	07·91
Other expenses	04·88	04·55	04·67	05·12
Total expenses per mile run	25·54	24·04	23·52	23·38
Net earned per mile run	07·85	11·25	14·81	13·64

Taking the June figures, it will be noticed that the net earnings per electric car mile exceed the net earnings per horse car mile by 10·07 cents, while the operating expenses of the horse car lines exceed those of the electric car lines by 4·21 cents per car mile. The difference is 5·86 cents per car mile, which is the gain to the company due solely to the public satisfaction with the electric service. Mr. Arthur Jones, of the T. H. International Company, first produced this figure, which he calls the "satisfaction figure."

The net earnings per electric car mile exceeded the net earnings per horse car mile by the following amounts:

In April	6·06	cents	per car mile.
" May	6·47	"	"	"
" June	10·07	"	"	"
Mean	7·54	"	"	"

The net earnings of the horse cars for the three months averaged 9·36 cents per car mile, hence the electric cars showed a gain of 80 per cent. in the net earnings per car mile over the horse cars.

For the three months, we have the following figures for the electric cars:

Total receipts	$432,947
" expenses	243,456
Percentage of expenses to receipts	56 p. c.

In St. Paul and Minneapolis, with a combined population of 350,000, there is to-day not one single horse car. Minneapolis has 120 miles of electric railways, all equipped with the overhead system, and St. Paul has 75 miles of electric railways and 15 miles of cable. Most of the cable mileage is to be abandoned and supplanted by electricity. The last car horse disappeared from the streets of Minneapolis in June of this year. The July report of the Minneapolis system shows:

Gross earnings	$107,571
" expenses	52,585
Net earnings	54,985
Percentage of expenses to receipts	49 p. c.

Cleveland, Buffalo, Rochester, Toledo, Omaha, Cincinnati and many other large cities are now operating their street cars almost exclusively with electric motors, and the universal testimony is favorable to the increased facilities afforded the public and the increased profit to the stockholders.

Not the least important of the developments of the last three years has been the financial development. The fine showings as to earnings, the gradual decrease in operating expenses, where increases were expected, the oft demonstrated ability to run electric cars in all kinds of weather, in ice, snow, sleet, hail or rain, has greatly improved the standing of electrical securities. An electric road is no longer an experiment, it is a paying investment; and there are not a few instances where the introduction of electricity has been the salvation of a horse road that otherwise would have soon been in the hands of a receiver. The rapidly increasing demand for electrical securities is an evidence of a healthy growth of public sentiment in this direction. To equip electrically means the expenditure of money which must come from an increase of the bonds or stocks issued. The ability of the public to rapidly absorb these new bonds or stocks must be the ultimate limit of the ability of the railway companies to move in this direction.

In August the West End Street Railway Company put out four millions of common stock for additional electrical equipment under a plan of subscription which provided for two deferred payments. When the subscription books were closed on the 5th of August, 33,000 shares had been paid in and only a paltry 245 shares had taken advantage of the option for deferred payments. I know of no more striking object lesson than this, except perhaps that the rapid rise of the West End common stock from 63 to 77, which immediately followed.

Electric securities have heretofore been offered at tempting figures, but the day for this is passing. The public are realizing that a good street railway security is better than a western railroad bond or stock, and the electric roads are better than the horse roads. Electric railways will pay where no one would dream of building a horse road, and when the public taste is whetted for electrical securities, we shall see a marvelous increase in the number of roads and the equipment of existing roads that will mean transportation facilities for thousands who are now unprovided, and many years' work for our electrical factories.

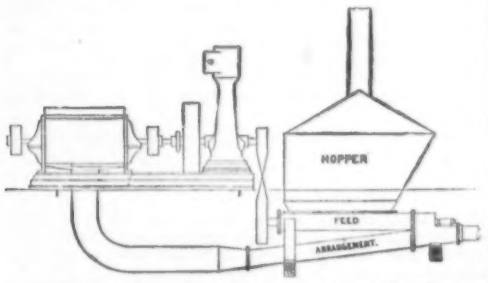
Mr. W. H. Hammer: This is an admirable paper, and contains a number of chronological events which deserved to go on record, but I think that some have been omitted. To say nothing of the experiments of Dr. Siemens, whose railroad is still running in Berlin, and which dates away beyond any that Captain Griffin has referred to, I might refer to the experiments made in

1881, in Paris, at the time of the Electrical Exposition. I believe the date given as the earliest in this paper was 1883. I have a very vivid recollection of an electrical railroad which was in operation in 1880 and 1881, a mile and a half in length, at Menlo Park, N. J., and which attained a speed of no less than 40 miles per hour, and within a very short time after that was extended to three and a half miles in length. It was such an elaborate experiment at that time, and of such great commercial value, that I think the fact should be put on record in connection with a paper of the importance that this is.

Mr. Griffin: I would like to say with reference to early experiments which I have referred to, that I did not intend that the list should be taken as complete. Perhaps I did not express it explicitly, but I intended to confine it simply to the United States. The car I refer to, on the Cleveland road—I intended to make that explicit—was the first car I know of that was in operation upon any existing street railway on the streets of a city. There were lots of experimental roads which were built in addition to those that I have mentioned, that were built for the purpose of demonstrating the feasibility and the possibility of operating street railways by electricity; but I think that car in Cleveland was the first car that was put into regular operation upon an existing street railway upon the streets of a city and put in schedule operation. That may be a small distinction, but such as it is, is one which Mr. Bentley and Mr. Knight have always delighted to make a great deal of.

MOVING COAL BY BLOWING.

A new use for the Root blower has been found in the removal of slack at coal mines and shipping localities. The plant consists of a Root positive blast



PNEUMATIC APPARATUS FOR MOVING SLACK COAL.

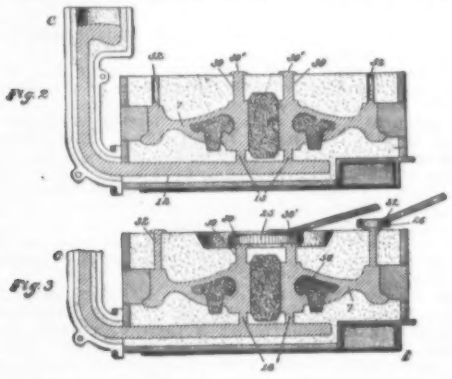
blower and an operating engine or belt in connection with the slack hopper, an attached worm discharge for the slack, and a blast pipe connected with the worm discharge.

The worm discharge from the hopper is operated by a belt from the engine, and is adjustable to move only such an amount of slack as can be taken care of by the blast. The operation is upon the same principle as the sand blast for file cutting and sharpening, and the maximum capacity of the plant can readily be determined. The method is clean and economical, and shows a saving of from six to eight dollars a day over cart or car and horse practice.

It can be used for the removal and collection of dust and refuse from ore concentration works, and for similar purposes. The refuse through the use of conveyor pipes can be discharged at any desired spot or locality. —*Railroad Gazette.*

IMPROVED PROCESS OF CASTING STEEL CAR WHEELS.

The author, William G. Richards, of Boston, Mass., arranges the mould so that the metal will overflow



through the hub vents before the rim is entirely filled and before the feeding of the rim is entirely finished. That result is obtained by making the set of hub vents, 30, to have a less "resistance" than the rim vents, 32, their position and distance from the mould filling passages, 13, being considered, and this may be accomplished by suitably graduating the size of the respective overflow passages, 30 and 32. The molten metal being poured into the pouring head, C, enters the mould at the under side of the hub space, and therefore naturally fills the central part of the mould most rapidly until it overflows the freer hub vents, 30, in the meantime flowing outward through the plate space, 7, of the mould, and at a later moment rising through the rim vents, 32, and finally overflowing the rim. One stage of this operation is illustrated where the metal is shown at 30', overflowing the hub vents, 30, while the rim is only just filled and not yet overflowed. At this moment, during the pouring operation, the workman suddenly checks the overflow at the hub vents, which may be done by means of a chill, as 25, placed on the outflowing metal over said vent. This chill by suddenly abstracting heat from the overflowed metal instantly checks the overflow, so that after a very brief time the chill may be removed. Later in the pouring operation and as a sub-process therein the rim vents are suddenly checked, thereby bringing the full pressure of the head of metal on to the rim for the feeding of the same after the plate spaces and hub space are fully filled. For checking the rim vents the same chill, 25, may be used as for the hub vents, or, if more convenient, a separate smaller chill, as 26, may be employed, this being used by the same or by another workman.

The overflow at the hub is an important aid to the making of sound wheels, since it tends to dislodge and carry out of the metal certain impurities; but it is detrimental to the later feeding of the rim. Accordingly during the pouring operation and after the hub overflow has sufficiently proceeded, I check the hub vents, and thereby direct the momentum of the moving fluid mass toward the rim, thus giving to the metal an impetus which materially promotes the effectiveness of the operations of filling and feeding the rim by more perfectly through-flowing the plate and rim juncture after the hub space is filled and the plate has begun contracting.

THE LOS ANGELES CABLE RAILWAY.

One of the most extensive cable-worked railroads in operation is that of Los Angeles, Cal., its length being about twenty-one miles of single track, worked by

Fig. 1.

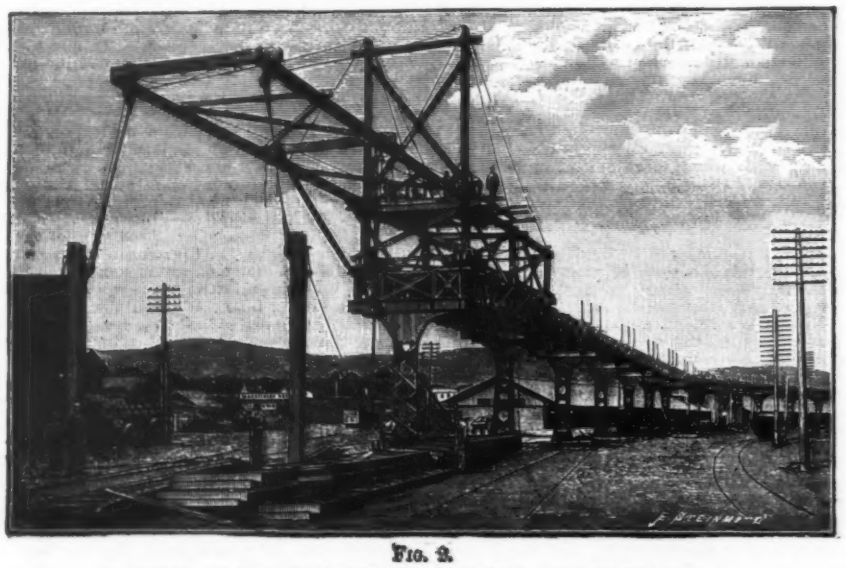


Fig. 2.

THE LOS ANGELES CABLE RAILROAD.

three power stations, all similar in design. In connection with this road, and serving as feeders, are twenty-four miles of horse-worked lines. The gauge is 3 ft. 6 in., and the rails, which are of steel, 40 lb. to the yard, are carried on iron sleepers. The channel in which the cable travels is made of cement concrete, and the slot rails on the top are of steel, and weigh 40 lb. per yard. The works on this line are of considerable interest, and include three viaducts, while the curves are numerous. One of the viaducts carries the line over the Santa Fe Railroad and the Los Angeles River, and is of considerable dimensions. The most important viaduct is that over San Fernando Street, and of which several views are here given.

The purpose of this structure is to carry the cable lines over the Southern Pacific Railway Company's yards. The plans for it were prepared by Mr. S. G. Artingstall, of Chicago, and a remarkable feature about it is that the road is supported on single columns. This form of construction was necessitated because of a refusal on the part of both the Southern Pacific Railway Company and the city authorities to permit the planting of posts where they would have been necessary if double columns had been used; and we believe that this viaduct is the only instance in existence where two tracks are carried on single columns, although in certain parts of the elevated railway structure in New York a single track is thus supported. The length of this viaduct is 1,535 ft., of which 50 ft. at each end are occupied by concrete approaches, and the remaining 1,435 ft. represent the length of the metal work. The viaduct affords no thoroughfare except for the cable cars, and in fact no other vehicles could travel over it, as the roadway is all openwork. The height from the ground to the rail level is 35 ft. 9 in., and the width between handrails is 25 ft. The main posts are 5 ft. wide at the ground line, tapering to 3 ft. at a height of 14 ft. above ground, and are 22 ft. long. There are 19 main posts, each weighing 4½ tons, and 10 smaller posts, 12 in. square and 20 ft. 6 in. long, making 29 posts in all. The ruling span is 50 ft., but there are two spans of 55 ft., three of 40 ft., one of 30 ft., and one of 20 ft. The main trusses are of the Warren type, 4 ft. deep, and weighing 100 lb. per running foot. The approaches are built of 15 I beams, each 25 ft. long, and weighing 50 lb. per foot. The foundation for each main foot is a solid concrete block 15 ft. long, 6 ft. wide, and 5 ft. 6 in. deep. Those for the smaller posts measure 3 ft. every way. The concrete part of the approaches is 8 ft. high at the highest point and 19 ft. wide. The grade on the approaches is about 18 per cent. There are two curves on the viaduct, each of 60 ft. radius to the center line, and at these points there are braced posts to take the strain, and the tracks are also carried on double posts at these points as well as at the approaches, as a precautionary measure.

Figs. 3 and 3 are perspective views of different parts of this viaduct and give a good idea of the construction, while Figs. 4 and 5 are details of the standards and superstructure.

The entire length of the straight surface tracks of the cable line is 99,328 ft.; of the viaducts, 4,250 ft.; of bridges, 2,134 ft.; of curves, 2,010 ft.; and of the pits, 562 ft.; making a total of 108,274 ft. of track, or rather over 20½ miles, and the construction required 1,444 tons of track and slot rails and 2,919 tons of iron sleepers.

As already stated, there are three power stations on the system, all similar in arrangement; they were completed by Messrs. Fraser & Chalmers, of Chicago, who have supplied engines to several of the cable companies in that city. The engines in the Los Angeles stations are compound, the high-pressure cylinder being 26 in. in diameter, and the low-pressure 42 in. in diameter; the stroke is 48 in.

They are intended to develop 700 horse power at a speed of 75 revolutions per minute. The high and low pressure cylinders are set side by side, and the distance between centers is 10 ft.; the total length of built-up crankshaft is ⅛ in. over 14 ft. The flywheel is 14 ft. in diameter with rim of 14 in. face by 18 in. deep, and weighs 36,000 lb.

The first driving shaft of the winding machinery is 18 ft. 2¼ in. long, with two journals at the ends and one in the center between the driving rope pulleys. In the bosses of these pulleys the shaft is swelled to 16 in.

in diameter. The rope wheels, which are two in number, are 6 ft. 1⅞ in. pitch diameter; they are made in halves, and are each grooved for fourteen 2 in. cotton ropes, the power of the engines being transmitted to the driven wheels by a system of endless rope transmission instead of by gearing. The large or driven rope wheels on the main rope shaft are 35 ft. in diameter, built up of ten segments each, with a hollow boss in one piece and ten hollow arms of elliptical section. The shaft which carries these wheels is 16 ft. 1½ inch long, the diameter in the boss of the wheels being 19¼ in. This shaft is coupled at each end to the winding shafts, which are 11 ft. 10¼ in. long, 17 in. in diameter in the center, and 15 in. at the bosses of the overhung rope drums. These latter are mounted on each end of the winding shaft, and each has two grooves for 2 in. cotton ropes, their diameter measured to the center of the rope being 15 ft. They drive two other rope wheels or "idlers," which are mounted on their own shaft; these idlers are of 1 in. less diameter than the driving rope drums, and the purpose of this is always to keep the cotton ropes taut, so that the

FIG. 3.

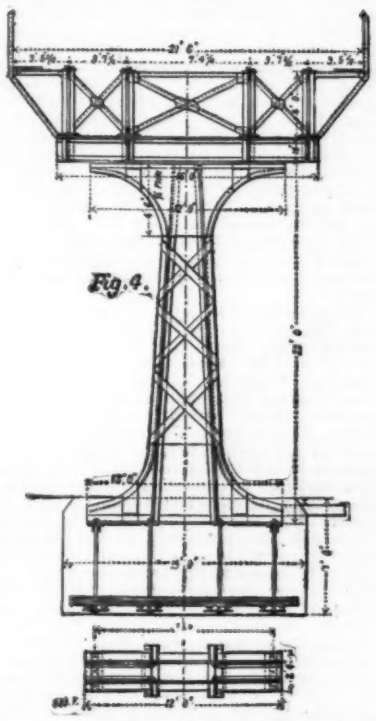


Fig. 4.

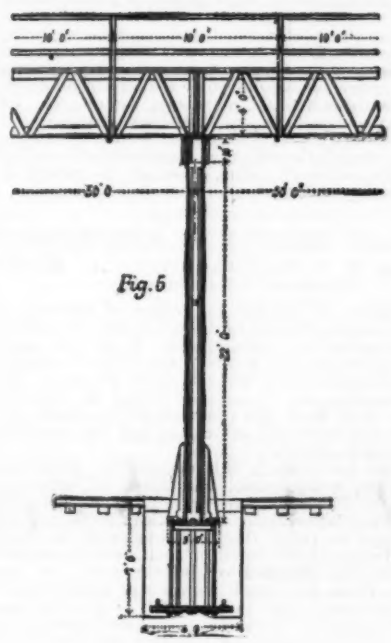


Fig. 5

THE LOS ANGELES CABLE RAILROAD.

cable itself may not have to perform any of the work of rotating the idler wheels, the necessary amount of slip required, as these slightly smaller wheels gain on the drivers, being provided for in the clutches with which the cable drums are driven. The cable drums are loose on the extended bosses of the rope wheels, and are held to these wheels by friction disks, which are tightened up by eight screws and handwheels in each drum. The cable drums on the winding shaft are 13 ft. in diameter with five grooves each for 1¼ in. cable, and those on the driven shaft are of the same diameter, but with four grooves in each. The cable speed corresponding to 75 revolutions per minute of the engines is 8½ miles an hour. We believe that this machinery is working in a very satisfactory manner, and that it reflects much credit on its builders, Messrs. Fraser & Chalmers.—*Engineering.*

POT-POURRI is a mixture of dried petals of roses, violets, etc., mixed with ⅛ its weight of salt. The leaves of fresh roses, etc., are collected and dried on porous paper in the sun; as soon as dry they are placed in a jar in layers alternating with the salt. Powdered orris root and extracts and many other ingredients may be added according to taste.

ON NICKEL CARBON OXIDE AND ITS APPLICATION IN ARTS AND MANUFACTURES.*

By LUDWIG MOND, F.R.S.

THE existence of a volatile compound of nickel and carbonic oxide was first discovered in my London laboratory in October, 1889, in the course of an investigation on which I was engaged with my assistants, Dr. Carl Langer and Dr. Friedrich Quincke, into the remarkable property of metallic nickel to induce, at the comparatively low temperature of 350 deg. C., the complete dissociation of carbonic oxide into carbon and carbonic acid, which, according to Victor Meyer and Carl Langer, by the application of heat alone remains incomplete at a temperature of 1690 deg. C. A very small quantity of nickel can effect the dissociation of a large quantity of carbonic oxide, and becomes converted into a very voluminous black mass containing varying quantities of carbon up to 85 per cent. This mass takes fire on exposure to air, so that we had to cool it under exclusion of air for the purpose of analysis, which was done in a slow current of carbonic oxide gas. This gas was subsequently led into a Bunsen burner, so as to keep it out of the atmosphere of the room. In this way we observed that when the cooling had proceeded to a certain point—about 150 deg. C.—the Bunsen flame became luminous and remained so, and even became intenser, down to ordinary atmospheric temperature. When the gas before entering the burner was heated in a glass tube, a metallic mirror was obtained, while the luminosity of the flame disappeared. We were at first inclined to refer this phenomenon to the presence in the nickel of an unknown element, perhaps to Kruss and Schmidt's gnomium, which at this time still haunted chemical literature. The metal of the mirror, however, gave all and every one of the reactions of nickel with remarkable brilliancy, and an approximate determination of the atomic weight came out so nearly to the very carefully determined figure of Russel for nickel—58·58 as compared with 58·74—that there could be no doubt about its identity with our well-known friend, whose character as a simple body, called in question by Kruss and Schmidt, was thus rehabilitated. In repeating the experiment with carbonic oxide, quite free from hydrogen and moisture, and only contaminated with nitrogen, the same result was obtained. After removing the carbonic oxide by cuprous chloride, and heating the residual gas to 180 deg. in aniline vapor, at which temperature nickel, quite free from carbon, is separated, we found the volume of gas to expand considerably, and the gas to contain only nitrogen and carbonic oxide. It was thus evident that we had obtained a volatile compound of nickel and carbonic oxide, which, on heating, dissociated into its constituents. The increase of volume proved that one volume of gas yielded four volumes of carbonic oxide, and the determination of the amount of nickel deposited and the carbonic oxide formed led to a proportion of four equivalents of carbonic oxide to one of nickel. To further study the properties of this compound it was necessary to produce larger quantities, which took us a long time to accomplish. By preparing the nickel in a very fine state of division, at the lowest possible temperature, by reducing the oxide, or, better still, the oxalate, in a current of hydrogen at about 400 deg. C., and by carefully purifying and regulating the current of carbonic oxide, we succeeded at last in forming the compound quite readily, and in obtaining a gas sufficiently rich that on passing it through a refrigerator, cooled by ice and salt, we condensed the compound to a liquid. This liquid is colorless, mobile, highly refracting, possesses a characteristic odor, and is very volatile. It is soluble in a large number of organic liquids, such as alcohol, ether, chloroform, benzole, petroleum, tar oils, etc. It boils at 43 deg. C. at 751 mm. pressure without decomposition, and evaporates rapidly at ordinary temperature in a current of other gases. The specific gravity is 1·3185 at 17 deg. C.; at —25 deg. it solidifies, forming needle-shaped crystals; the pure vapor explodes when suddenly heated to above 60 deg., and even when the tube containing it is scratched roughly with a file. A mixture of the vapor with air explodes violently on the application of a flame. Both the liquid and the vapor are poisonous, the latter approximating carbonic oxide in this respect. According to an investigation kindly undertaken by Professor McKendrick, the liquid dissolved in chloroform produced, when injected subcutaneously in extremely small doses in rabbits, an extraordinary reduction of temperature, amounting in some cases to 12 deg. C. Careful determination of the quantity of nickel contained in the liquid, made by introducing a weighed quantity into chlorine water and precipitation of the nickel from the resulting solution, led to figures agreeing very closely with the formula $Ni(CO)_4$, viz., 34·33 and 34·26 per cent. of nickel, the formula requiring 34·28. The vapor density determined by Victor Meyer's method at 50 deg. was found equal to 6·01; the formula $Ni(CO)_4$ requires 5·89.

The compound is chemically very inactive; generally speaking, it only reacts with substances having a considerable affinity for nickel, such as the halogens, sulphur, oxygen, and oxidizing substances, which combine with the nickel and liberate carbonic oxide. Chlorine and bromine when used in excess also enter into combination with the carbonic oxide. Sulphur in the dry state forms a sulphide of nickel corresponding to the formula Ni_2S_2, and dissolved in bisulphide of carbon it forms a sulphide containing more sulphur, but of varying composition. Selenium acts similarly but very slowly. Tellurium shows hardly any action. Metals—even potassium—are not acted upon. Alkalies and acids—even strong hydrochloric acid—produce no change except they are oxidizing agents, such as nitric acid and aqua regia. With metallic salts no reaction is obtained unless they have oxidizing properties as hypochlorites, which form a higher oxide of nickel, or they are capable of giving off sulphur, such as hyposulphites and bisulphites. We have tried in vain to substitute the carbonic oxide in this compound by other bivalent groups, or to introduce the carbonic oxide by means of this compound into organic substances. Our experiments in this direction have covered a very wide range and have included, among others, the following: Hydroxylamine, hydrochloride, phenylhydrazin hydrochloride hydroxylamine, dichloracetic acid, tetrabromphenolbromide, ethylenechloride and acetoacetic ether, but in no single instance have we succeeded in obtaining the desired result.

On exposure to moist or dry air a flocculent substance, which varies in color from a light green to a dark brown, is very slowly formed. This substance dissolves completely in dilute acids with evolution of carbonic acid; numerous analyses have not led to a definite proportion between Ni and CO_2 in this compound. On heating it to dull red heat it turns black. Professor Berthelot, in a paper recently communicated to the French Academy of Sciences, assumes that this black color is produced by the separation of carbon, and bases upon this an argument that the compound is of a complex composition, and that the nickel carbon oxide, on exposure to air, behaves like a real compound radical analogous to organo-metallic radicals. As, however, the black substance so obtained dissolves in dilute acids without leaving any residue, and as an exactly similar black substance is obtained by heating precipitated nickel carbonate, this argument does not seem to be conclusive, and I must regret that Professor Berthelot has not substantiated so important a conclusion by a complete analysis of the black substance.

Professor Berthelot describes in the same paper a very beautiful blue compound obtained by treating nickel carbon oxide with nitric oxide. Unfortunately he does not publish an analysis of this beautiful substance either, so that until he has done so we are unable to judge of its bearing on the constitution of nickel carbon oxide. With a view to elucidate this constitution I have, in conjunction with Professor R. Nasini, of Rome, studied the physical properties of the liquid, more especially its refraction and dispersion. The details of this investigation have been communicated to the Academia dei Lincei at Rome, and have also been published in the *Journal fur Physikalische Chemie.*

We have determined the freezing point of a dilute solution in benzole containing 4·8991 per cent., and have found the coefficient of diminution 0·2776, corresponding to a molecular weight of 176·5; while nickel carbon oxide requires 170·6. The mean cubical coefficient of expansion between 0 deg. and 36 deg. C. we found equal to 0·001853, which is one of the highest coefficients of expansion yet found for any liquid, and

*British Association, Section B.

is only slightly exceeded by ethylic ether, ethyl chloride and silicum tetrachloride. We have determined the refraction, and the dispersion of the lines α, β, and γ of hydrogen, and for the lines of lithium, sodium, and thallium at three different temperatures, and have found both to be very high. The dispersion is about the same as carbon disulphide. The refraction varies very much with the temperature, the amount of variation being very nearly equal to that of carbon disulphide. The refraction for the D line at 10 deg. C. is 1·45843. According to Gladstone's formula this leads to the specific refraction of 0·3437, and the molecular refraction of 58·63. Under the supposition that the group CO had the same value in our compound which results from the sum of the atomic refraction of carbon and that of the divalent oxygen molecule in organic compounds, which is more probable, as the group CO shows very nearly the same molecular refraction in compounds of the most different constitution, such as oxalic acid, ketones, and carbonyldichloride, the atomic refraction of nickel would come out equal to 25·02. This figure is very much higher, nearly two and a half times as high as it is in nickel salts, in which it has been found by Gladstone to be about 10; and about four times as high as the atomic refraction of metallic nickel as determined by Kundt and Dubois and Rubens, viz., about 6.

This difference of the atomic refraction of nickel in our compound and in its ordinary combinations is by far greater than that found in any other element. According to the generally accepted view, such differences are due to the element exercising a larger number of valencies, and are proportioned to the number of valencies thus exercised. Nickel is generally bivalent. Its very high atomic refraction in nickel carbon oxide would thus lead to the conclusion that in this compound the nickel exercises a considerably higher valency than two, and that it has probably reached its maximum of saturation foreseen by Mendeléef, who placed this metal in the eighth group of his Periodic System, to be equal to eight; so that the constitution of our compound would be a simple combination of one octovalent equivalent of nickel with four bivalent equivalents of carbonic oxide, or that of nickel tetra-carbonyl. All that we definitely know of the chemical properties of the compound is in accord with this view of its constitution.

A determination of the magnetic rotary power of the compound kindly made by Dr. W. H. Perkin has shown this to be quite as exceptional as its refraction, and, with the exceptional phosphorus, greater than any substance he has yet examined. Professor Quincke, of Heidelberg, has had the kindness to investigate the magnetic properties of the liquid. He found the constant of diamagnetism at 16 deg. C. $k = -3{\cdot}131 \times 10^{-10}$ for magnetic fields of 6,000 to 14,000 C. G. S. units. This is nearly the same as the constant for ethylic ether $= -3\,218 \times 10^{-10}$. The liquid is an exceptionally bad conductor of electricity. Up to 40 volts no current was observed to pass, the electrodes of square cm. area being 1 cm. apart.

The highly interesting properties of nickel carbon oxide naturally led us to try whether we could not obtain similar compounds of other metals. It seemed a foregone conclusion that cobalt, in every respect so much like nickel, must give an analogous compound. It seemed probable that other metals of the eighth group, and those standing near to nickel in other groups, would also combine with carbonic oxide. We tried a large number of elements, including osmium, palladium, ruthenium, rhodium, iridium, and manganese, by acting upon them in the finely divided state with carbonic oxide gas over a wide range of temperature. We tried it by double decomposition with numerous compounds, including zinc ethyl and mercury methyl; but, with one sole and single exception, without success. This sole exception is iron. This metal, too, had for a long time given us negative results; but by preparing it at the lowest possible temperature by reduction of the oxalate in a current of hydrogen, and by acting upon this at about 80 deg. C. with a very slow current of very pure carbonic oxide, I succeeded at last, in conjunction with Dr. F. Quincke, in obtaining evidence that a volatile compound of this element with carbonic oxide exists. The gas obtained imparted a yellow tinge to a Bunsen flame, and yielded slight metallic mirrors composed of pure iron. The quantity of iron compound in the gas was, however, extremely small. By passing the gas through heavy tar oils, in which the compound is soluble, but from which it cannot be separated by fractionation, as it decomposes on heating the solution into iron and carbonic oxide before it volatilizes, and by determining the iron and carbonic oxide so obtained, we ascertained, as far as the very small quantities of the substance at our disposal would allow, that it contained iron and carbonic oxide in the proportion of 1 equivalent of iron to 4·126 of carbonic oxide, or very nearly 1 to 4. Since these results were communicated to the Chemical Society—18th June, 1891—I have continued the study of this body, in collaboration with Dr. Carl Langer, and we have arrived at obtaining it as an amber colored liquid, which, on standing, deposits tabular crystals of a darker color, and solidifies entirely below —21 deg. C. to a mass of needle-shaped crystals. It boils at 102 deg. C., but leaves a small quantity of green colored oil behind. We have made several analyses and vapor density determinations, but are not yet certain whether we have a pure substance in hand or a mixture of several iron carbonyls. We hope to be able very shortly to publish a full account of this interesting substance, which differs considerably in its chemical behavior from nickel carbon oxide.

The fact that under ordinary circumstances nickel alone is acted on when a mixture of this metal with any other metallic or mineral substances is treated by carbonic oxide gas, led me to institute experiments to ascertain whether it would not be possible by means of carbonic oxide to extract nickel direct from its ores, and such metallurgical products as nickel speiss and nickel matte. As the nickel is volatilized at the ordinary temperature in the form of a vapor disseminated through other gases from which it can be deposited without first condensing the nickel compound by simply heating these gases to the moderate temperature of 200 deg. C., as it is thus obtained in the form of bright coherent masses of great purity, as the carbonic oxide used is completely liberated and can be employed over and over again, and as small quantities of the poisonous nickel compound which may escape decomposition would thus never leave the closed apparatus in which the process would be carried out, it seemed probable that such a process might be capable of industrial application, and might prove more economical than the very complicated operations metallurgists have now to resort to, to produce tolerably pure nickel.

Experiments carried out under my instructions by Dr. Langer with a great variety of nickel ores from all parts of the world, containing from 4 to 40 per cent. of nickel, as well as a number of samples of nickel speiss and nickel matte, have proved that as long as the nickel is combined with arsenic or sulphur the process is entirely successful on a laboratory scale. In the majority of cases I have been able to extract the nickel almost entirely in three to four days. Such ores or matte or speiss have in the first instance to be calcined, so as to convert the nickel completely into oxide. The mass is then reduced in a current of hydrogenous gases, in practice water gas, at a temperature of 450 deg. C. It is cooled down to ordinary temperature and treated with carbonic oxide in a suitable apparatus. For this purpose any good apparatus for treating solids by gases, of which a great number are in common use, will answer. Methodical apparatus moving the reduced ore in opposite directions to the current of carbonic oxide, at the same time exposing fresh surfaces, facilitate the operation. After a certain time the action of the carbonic oxide upon the nickel becomes sluggish. The mass is then heated to about 350 deg. C. in a current of carbonic oxide, which regenerates the activity of the nickel. This may be done in the same apparatus, but it is preferable to use a separate apparatus connected with the first, and from which it is returned to the first by mechanical means, so that each apparatus can be kept at the same temperature. The carbonic oxide gas can be employed dilute, as it is obtained from gas producers; but since it is continuously recovered, a purer gas such as can be cheaply prepared by passing carbonic acid through incandescent coke is more advantageous, as it extracts the nickel more quickly and requires smaller apparatus. The gas charged with the nickel compound leaving the apparatus is passed through tubes or chambers heated to about 200 deg. C., in which the nickel is deposited. The gas leaving these tubes is returned to the first apparatus, and circulates continuously. From time to time the nickel is removed from the tubes in which it has been deposited. To facilitate this operation thin nickel sheets bent to fit the tubes are inserted, on which the nickel deposits, and which are easily taken out. The metal so obtained is almost chemically pure; only very rarely in the case of certain ores it is slightly contaminated with iron. Its density is equal to that of ordinary sheet nickel. Its mechanical properties still await investigation. As the nickel is deposited in perfectly coherent films upon heated surfaces exposed to the gas containing the nickel carbon oxide, I have found it possible to produce direct from such gas articles of solid nickel or goods plated with nickel resembling in every way those obtained by galvanic deposition of metals, and reproducing with the same exactitude and fineness any design upon such articles. This result can also be obtained by immersing heated articles in a solution of nickel carbon oxide in such solvents as benzole, petroleum, tar, oils, etc., or by applying such solution to the heated articles with a brush or otherwise. These processes open up a wide perspective of useful application, considering the many valuable properties of nickel, especially its power of resisting atmospheric and other chemical influences.

THEORY AND PRACTICE IN METALLURGY.*

By Professor W. C. Roberts-Austen, C.B., F.R.S., President of the Section.

The selection of Cardiff as a place of meeting of the British Association led to the presidency of Section B being intrusted to a metallurgist. It will be well, therefore, to deal in this address mainly with considerations connected with the subject to which my life has been devoted, and I hope that it may be possible for me to show that this practical art has both promoted the advancement of science and has received splendid gifts in return.

It is an art for which in this country we have traditional love; nevertheless, the mode of teaching of it, and its influence on science, are but imperfectly understood and appreciated. Practical metallurgists are far too apt to think that improvements in their processes are mainly the result of their own experience and observation, unaided by pure science. On the other hand, those who teach metallurgy often forget that for the present they have not only to give instruction in the method of conducting technical operations, but have truly to educate, by teaching the chemistry of high temperatures, at which ordinary reactions are modified or even reversed, while they have further to deal with many phenomena of much importance, which cannot, as yet, be traced to the action of elements in fixed atomic proportions, or in which the direct influence of the atom is only beginning to be recognized.

The development of a particular art, like that of an organism, proceeds from its internal activity; it is work which promotes its growth, and not the external influence of the environment. In the early stage of the development of an industry the craftsmen gather a store of facts which afford a basis for the labors of the investigator, who penetrates the circle of the "mystery" and renders knowledge scientific. Browning, inspired by the labors of a chemist, finely tells us in his "Paracelsus":

> To know
> Rather consists in opening out a way
> Whence the imprisoned splendor may escape,
> Than in effecting entry for a light
> Supposed to be without.

If it be asked who did most in gaining the industrial treasure and in revealing the light of chemical knowledge, the answer is certainly the metallurgists, whose labors in this respect differ materially from others which have ministered to the welfare of mankind. First it may be urged that in no other art have the relations between theory and practice been so close and enduring. Bacon, who never undervalued research, tells us that in the division of the labor of investigation in the New Atlantis there are some that "raise the former discoveries by experiments into greater observations, axioms, and aphorisms: these we call the *interpreters of nature*." There are also others that "bend themselves, looking into the experiments of their fellows and casting about how to draw out of them things of use and practice for man's life and knowledge . . . these we call the *dowry men or benefactors*." In reviewing the history of metallurgy, especially in our islands, it would seem that the two classes of workers, the interpreters of nature and the practical men, have for centuries sat in joint committee, and, by bringing theoretical speculation into close connection with hard industrial facts, have "carried us nearer the essence of truth."

The main theme of this address will therefore be the relation between theory and practice in metallurgy, with special reference to the indebtedness of the practical man to the scientific investigator.

We will then consider—

(1) Certain facts connected with "oxidation" and "reduction," upon which depend operations of special importance to the metallurgist.
(2) The influence in metallurgical practice of reactions which are either limited or reversible.
(3) The means by which progress in the metallurgic art may be effected, and the special need for studying the molecular constitution of metals and alloys.

(1) The present year is a memorable one for chemists, being the centenary of the birth of Faraday and the bicentenary of the death of Robert Boyle. The work of the former has recently been lovingly and fittingly dealt with in the Royal Institution, where he labored so long. I would, in turn, briefly recall the services of Boyle, not, however, on account of the coincidence of date, but because with him a new era in chemistry began. He knew too much about the marvelous action of "traces" on masses of metal to feel justified in pronouncing absolutely against the possibilities of transmutation, but he did splendid service by sweeping away the firm belief that metals consist of sulphur, salt, and mercury, and by giving us the definition of an element. He recognized the preponderating influence of metallurgy in the early history of science, and quaintly tells us that "those addicted to chemistry have scarce any views but to the preparation of medicines or to the improvement of metals," a statement which was perfectly correct, for chemistry was built up on a therapeutic as well as a metallurgic basis. The fact is, however, that neither the preparation of materials to be employed in healing, nor the study of their action, had anything like the influence on the growth of theoretical chemistry which was exerted by a few simple metallurgical processes. Again, strange as it may seem, theoretical chemistry was more directly advanced by observations made in connection with methods of purifying the precious metals, and by the recognition of the quantitative significance of the results, than by the acquisition of facts incidentally gathered in the search for a transmuting agent. The belief that chemistry "grew out of alchemy" nevertheless prevails, and has found expression in this section of the British Association. As a fact, however, the great metallurgists treated the search for a transmuting agent with contempt, and taught the necessity of investigation for its own sake. George Agricola, the most distinguished of the sixteenth century metallurgists, in his "De Ortu et Causis Subterraneorum" (lib. v.), written about the year 1539, disdainfully rejects both the view of the alchemists that metals consist of sulphur and mercury, and their pretended ability to change silver into gold by the addition of foreign matter.

Biringuccio (1540) says: "I am one of those who ignore the art of the alchemists entirely. They mock nature when they say that with their medicines they correct its defects, and render imperfect metals perfect." "The art," he adds, "was not worthy of the consideration of the wise ancients who strove to obtain possible things." In his time, reaction between elements meant their destruction and reconstitution, nevertheless his sentence "transmutation is impossible, because in order to transmute a body you must begin by destroying it altogether," suggests that he realized the great principle of the conservation of mass upon which the science of chemistry is based. We have also the testimony of the German metallurgist, Becher, who improved our tin-smelting in Cornwall. He is said to have caused a medal to be struck in 1675, which bore the legend: "Hanc unciam argenti finissimi ex plumbo arte alchymica transmutavi," though he should have been aware that he only extracted the precious metal from the lead, and had not transmuted the base one. This is a lapse which must be forgiven him, for his *terra pinguis* was the basis of the theory of Phlogiston, which exerted so profound an influence for a century after his death, and he wrote: "I wist that I have got hold of my pitcher by the right handle, for the pseudo-chemists seek gold, but I have the true philosophy, science, which is more precious."

At this critical period what was Boyle doing when the theory of Phlogiston dawned in the mind of the metallurgist Becher? In 1672 Boyle wrote his paper on "Fire and Flame Weighed in the Balance," and came to the conclusion that the "ponderous parts of flame" could pass through glass to get at melted lead contained in a closed vessel. It has been considered strange that he did not interpret the experiment correctly, but he, like the phlogistic chemists, tried to show that the *subtilis ignis*, the material of fire or phlogiston, would penetrate all things, and could be gained or lost by them. Moreover, his later experiments showed him that glass was powerless to screen iron from the "effluvium of a loadstone." His experiment with lead heated in a closed glass vessel was a fundamental one, to which his mind would naturally revert if he could come back now and review the present state of our knowledge in the light of the investigations which have been made in the two centuries that have passed since his own work ceased. If he turned to the end of the first century after his death, he would see that the failure to appreciate the work of predecessors was as prevalent in the eighteenth century as in the sixteenth. The spirit of intolerance which led Paracelsus to pub-

* Address to the Chemical Section of the British Association, Cardiff, 1891.

licly burn, in his inaugural lecture at Basle, the works of Galen, Hippocrates, and Avincenna, survived in the eighteenth century when Madam Lavoisier burnt the works of Stahl, but it was reserved for the nineteenth century to reverently gather the ashes, recognizing that when the writers of the school of Becher spoke of Phlogiston, they meant what we understand by potential energy.

If Boyle, finding that the Fellows of the Royal Society had not carried out their intention to build a "Repository and Laboratory," sought the School of Mines and came to the Royal College of Science, he would surely thank my colleague, Professor Thorpe, for his vigorous defense last year, as president of this section, of the originality of the work of Priestley and Cavendish, to which Boyle's own researches had directly led. We, on our part, remembering Berzelius's view that "oxygen is the center point round which chemistry revolves," would hope to interest him most by selecting the experiments which arose out of the old metallurgical operation of separating the precious metals from lead by "cupellation." When, in conducting this operation, lead is heated in the presence of air, it becomes converted into a very fluid dross. Boyle had, in 1661, taken this operation as the very first illustration to his "Sceptical Chemist" in proof of his argument as to the elemental nature of metals. He would remember the quantitative work of Geber in the eighth century, who stated that the lead so heated in air acquired a "new weight," and he would appreciate the constant reference to the operation of cupellation from the close of the sixth century B. C., when the Prophet Jeremiah wrote, to the work of Jean Rey in 1629, whose conclusions he would wish he had examined more closely. Lord Brouncker, as first President of the Royal Society, had called attention to the increase in weight of the lead in the "coppels" in the Assay Office in the Mint in the Tower, and Mayo had shown that the increase in weight comes from a distinct "*spiritus*" in the air. Boyle would incidentally see that Newton had accepted office in the Mint, where he doubtless continued his experiments on calcination, begun some time before, and, as if to mark his interest in the operation of assaying, figures are represented on a bass-relief on his tomb in Westminster Abbey as conducting cupellation in a muffle. The old work merges wonderfully into the new. Chevreul, in the nineteenth century, confirms Otto Tachens' view in the seventeenth, as to the saponifying action of litharge. Deville employs molten litharge to absorb oxygen dissociated from its compounds, and Graham, by extracting occluded gases from iron and other metals, proves the accuracy of the old belief that elastic fluids can freely permeate even solid metals.

We may imagine with what vivid interest Boyle would turn, not merely to the results of Priestley's work, but to his methods. Priestley had decomposed litharge with the electric spark, and had satisfied himself in 1774, by heating red lead, that the gas he obtained in his earlier experiments was really the one now called oxygen.

Boyle would see that in the period 1774–77 Lavoisier, being attracted by the "sceptical chemist's" own experiment on the heating of lead in closed vessels, overthrew the Phlogistic theory and placed chemistry on a firm basis by showing that the increase in weight of lead and tin, when heated in air, represents exactly the weight of the gaseous body added, and, finally, Dalton having developed the atomic theory and applied it to chemistry, Berzelius made lead memorable by selecting it for the first determination of an atomic weight.

Without diverting his attention from the phenomena of oxidation, Boyle would find questions the interest of which is only equaled by their present obscurity. He would contemplate the most interesting phase of the history of chemical science, described by Vant' Hoff as that of its evolution from the descriptive to the rational period, in the early days of which the impossibility of separating physics and chemistry became evident, and Boyle would find that chemistry is now regarded from the point of view of the mechanics of the atoms.

Deville's experiments on dissociation have rendered it possible to extend to the groups of atoms in chemical systems the laws which govern the fusion and vaporization of masses of matter, and this has produced a revolution comparable in importance to that which followed the discovery of the law of definite proportions, for dissociation has shown us that true causes of chemical change are variations of pressure and of temperature. For instance, oxygen may be prepared on an industrial scale from air by the intervention of oxide of barium heated to a constant temperature of 700° provided air be admitted to the heated oxide of barium, under a pressure of 1½ atmospheres, while the oxygen thus absorbed is evolved if the containing vessel be rendered partially vacuous. It will be evident, therefore, that at a certain critical temperature and pressure the slightest variation of either will destroy the equilibrium of the system and induce chemical change.

The aim of Boyle's chemical writings was to show that no barrier exists between physics and chemistry, and to "serve the commonwealth of learning by begetting a good understanding betwixt the chemists and the mechanical philosophers," who had, as he said, "been too great strangers to each other's discoveries." In view of the dominant lines of research which occupy chemists at the present time, such, for instance, as the investigations of "Osmotic pressure" and of the application of Boyle's own law to salts in solution, he would feel that his hope had been realized, and that, though he lived a century too soon to take part in Berthollet's discussion with Proust, he nevertheless shares Berthollet's triumph in the long delayed but now rapid development of chemistry as a branch of applied mechanics.

We need, however, no longer look at these questions from the point of view of Boyle, for our own interest in the application of chemical mechanics to metallurgy is sufficiently vivid, as instances to be given subsequently will show.

Hitherto I have mainly dwelt on questions relating to oxidation, but not less interesting is the history of the steps by which an accurate knowledge was acquired of the other great process practiced by the metallurgist, the one to which Paracelsus was the first to apply the name of "Reduction." Its explanation followed naturally from the elucidation of the phenomena of combustion by Lavoisier, who, in continuation of Macquer's experiments of 1771, proved, in conjunction with other workers, that carbonic anhydride is produced when the diamond is burnt in air or oxygen. Carbon has been known for ages as the most important of the reducing agents, but when, in 1772, Lavoisier heated oxide of lead and carbon together, he did not at first recognize that carbonic anhydride had been produced, simply because the volume of the gas set free was the same as if oxygen merely had been liberated. He soon, however, saw that neither the carbon alone, nor the oxide of lead alone, gave rise to the evolution of carbonic anhydride, which resulted from the *mutual action* of carbon and a constituent of the litharge. "This last observation leads us insensibly," he adds, "to very important reflections on the use of carbon in the reduction of metals." It most certainly did, and by 1815 an accurate, if incomplete, view of reduction had passed into the encyclopædias. It was seen that the removal of oxygen from burnt metals by carbon, "give the metals," as Fourcroy and Vauquelin put it, "a new existence." Some ten years later Le Play attempted to show that reduction is always effected by the intervention of carbonic oxide, which elicited the classical rejoinder from Gay Lussac, who pointed out that "carbon alone, and at very moderate temperatures, will reduce certain metallic oxides without the intervention of carbonic oxide or of any other elastic fluid." I mention these facts because metallurgists are slow to recognize their indebtedness to investigators, and too often ignore the extreme pains with which an accurate knowledge has been acquired of the principles upon which their processes have been based.

The importance of a coherent explanation of reduction in smelting pig-iron is enormous. The largest blast furnaces in 1815 hardly exceeded those in use in the previous century, and were at most only 40 feet high with a capacity of 5,000 cubic feet. At the present day their gigantic successors are sometimes 90 feet high with a capacity of 25,000 cubic feet. This development of the blast furnace is due to the researches of a number of investigators, among whom Von Tunner, Lowthian Bell, and Gruner deserve special mention. We are, however, forcibly reminded of the present incompleteness of our knowledge of the mechanism of reduction, when we remember that the experiments of H. P. Baker have led us to believe that pure carbon cannot be burnt in perfectly dry and pure oxygen, and therefore that the reducing agent, carbonic oxide, cannot be produced at all unless moisture be present.

Ludwig Mond, Langer, and Quincke teach us not only that nickel can separate carbon from carbonic oxide, but the wholly unexpected fact that dry carbonic oxide can at a temperature of 100° take up nickel which it again deposits if heated to 150°. Mond and Quincke, and independently Berthelot, have since proved the existence of the corresponding compound of iron and carbonic oxide, and it may safely be concluded that in the blast furnace smelting iron this peculiar action of carbonic oxide plays an important part, and it doubtless aids the carburization of iron by cementation. It is truly remarkable that the past year should have brought us so great an increase in our knowledge of what takes place in the reduction of an oxide of iron, and in the carburization of the liberated metal. My own experiments have, I trust, made it clear that iron can, at an elevated temperature, be carburized by the diamond *in vacuo*; that is, in the absence of anything more than "a trace" of an elastic fluid or of any third element. Osmond has further shown, within the last few months, that the action between iron and carbon is a mutual one; for though carbon in the pure diamond form carburizes iron, the metal in its turn, at a temperature of 1050°, attacks the diamond, invests it with a black layer, and truly unites with it.

The question of the direct carburization of iron (Darby's process) by filtering the molten metal through carbon promises to be of much importance, for at present, as is well known, two millions of tons of steel, which are made in the Bessemer converter in this country alone, are recarburized after "the blow" by the addition of spiegeleisen.

Carbonic oxide, moreover, would appear to be more chemically active than had been supposed; for during the present year Berthelot has shown that the perfectly pure gas heated to 500° or 550° produces carbonic anhydride with deposition of carbon at red heat, not by ordinary dissociation, but by decomposition preceded by polymerization. He further shows that carbonic oxide will decompose ammoniacal nitrate of silver, and thus brings it into close connection with the aldehyds.

INFLUENCE OF REACTIONS.

(2) In turning to the modern aspects of metallurgical practice, we shall see that the whole range of the metallurgist's field of study is changing. It is no longer possible for him to devise a series of operations on the evidence afforded by a set of equations which indicate the completion of an operation: he has, as I have already suggested, to consider the complicated problems which have been introduced into chemistry from the sciences of physics and mechanics. He has in fact no longer to deal merely with atoms and molecules, but with the influence of mass. As Ostwald points out, we are reminded that many chemical processes are reciprocating, so that the original products may be obtained from the product of the reaction. The result of such opposed processes is a state of chemical equilibrium, in which both the original and the newly formed substances are present in definite quantities that remain the same so long as the conditions, more especially temperature and pressure, do not undergo further change. Again, in very many metallurgical processes, reactions are rendered incomplete by the limitations imposed by the presence of bodies which cannot be speedily eliminated from the system, and the result may be to greatly retard the completion of an operation. The time has come when the principles of dynamic chemistry must be applied to the study of metallurgical problems if they are to be correctly understood, and it is, moreover, necessary to remember the part played by the surface separating the different aggregates in contact with one another. When, for instance, a reaction has to take place accompanied by the evolution of gas, there must be space into which the gas can pass. The rate, therefore, at which change takes place will obviously depend on the state of division of the mass.

One of the most remarkable points in the whole range of chemistry is the action engendered between two elements capable of reacting by the presence of a third body. It may be, and this is the most wonderful fact of all, that merely a trace of a third body is necessary to induce reaction, or to profoundly modify the structure of a metal. H. Le Chatelier and Mouret have pointed out that in certain cases it is inaccurate to say that the third body causes the reaction to take place, because, after it has destroyed the inter-molecular resistances, which prevented the reaction taking place, the third body ceases to intervene. This is apparently the case when platinum sponge effects the union of oxygen and hydrogen, or conversely, when very hot platinum splits up water vapor into its constituent gases. Future investigation will, it is to be hoped, show whether the platinum does not exert some direct action in both cases. We can no longer neglect the study of such questions from the point of view of their practical application. The manufacture of red lead presents a case in point. In "drossing" molten lead the oxidation of the lead is greatly promoted by the presence of a trace of antimony, and conversely, in the separation of silver from molten lead by the aid of zinc, H. Roessler & Endelmann have recently shown that aluminum has a remarkable effect in protecting the zinc from loss by oxidation, and, further, the presence of one thousandth part of aluminum in the zinc is sufficient to exert this protecting action on that metal. I am satisfied that if our metallurgists are to advance their industrial practice, they must, if I may use such an expression, persistently think in calories, and not merely employ the ordinary atomic "tools of thought." They will then be able to state what reactions can under given conditions take place; to indicate those which will be completed; and to avoid those that are impracticable.

In France, the country of so many great metallurgists, men like Le Chatelier and Ditte are doing admirable service, by bringing the results of the labors and teachings of Ste. Claire Deville within the range of practical men. And if I do not refer more specifically to their work it is for want of space and not of appreciation, but a few simple cases of reversible actions will perhaps make the subject clear. In the blast furnace the main reducing agent, carbonic oxide, is produced from the solid fuel by the reaction $CO_2+C=2CO$, a reaction which is theoretically impossible because it is endothermic, and would be attended by absorption of heat. But heat external to the system intervenes, and acts either by depolymerizing the carbon into a simpler form which can combine with oxygen of the CO_2 with evolution of heat, or, by dissociating carbonic anhydride, sets oxygen free, which combines with the carbon. Reduction of oxide of iron in the blast furnace is mainly effected by carbonic oxide according to the well known reaction—

$$Fe_2O_3+3CO=2Fe+3CO_2$$

But the gas issuing from a blast furnace contains carbonic oxide, an important source of heat. The view that this loss of carbonic oxide was due to the fact that the contact of the ore and the reducing gas was not sufficiently prolonged led to a great increase in the height of blast furnaces, but without, as Gruner showed, diminishing the proportion of carbonic oxide escaping from the throat. The reduction of an iron ore by carbonic oxide only takes place within certain well-defined limits, and a knowledge of the laws of chemical equilibrium would have saved thousands and thousands of pounds which have been wasted in building unduly high furnaces. I would add that large sums have also been sacrificed in the vain attempt to smelt oxide of zinc in the blast furnace, for which operation patents have frequently been sought, in ignorance or defiance of the readiness with which the inverse action occurs, so that the reducing action of carbon on oxide of zinc may be balanced by the re-oxidation of the reduced zinc by carbonic anhydride, which is the product of the reduction. A further instance may be borrowed from an electro-chemical process which has been adopted for obtaining alloys of aluminum. As is well known, all attempts to effect the direct reduction of alumina by carbon have failed, because the reaction—

$$2(Al_2O_3)+3C=4Al+3CO_2,$$

requires 783·2 calories, while only 291 calories would result from the conversion of carbon into carbon anhydride, therefore the reaction cannot be effected; but in Cowles' process aluminum is, nevertheless, liberated when alumina is mixed with charcoal and strongly heated by the passage of an electric current. This result is due, not to a simple reduction of alumina, but to its dissociation at the high temperature produced by the passage of a current of 1,600 amperes between carbon poles, the liberated aluminum being at once removed from the system by metallic copper, which is simultaneously present, and may not be without action itself.

An instance of the importance of these considerations is presented in the manufacture of steel by the basic process. Much care is devoted to obtaining conditions which will insure not only the elimination, but the order of the disappearance of the impurities from the molten pig iron. In the basic process, as conducted in the closed converter, the phosphorus does not disappear until the carbon has left the fluid bath, while, when the open hearth furnace is used, the elimination of the phosphorus may be effected before that of the carbon, and it is asserted that if the carbon goes before the phosphorus is got rid of, a further addition of carbon is necessary. A curious and subtle case of chemical equilibrium is here presented. In the open hearth furnace and Bessemer converter respectively, the temperatures and pressures are different, and the conditions as to the presentation of oxygen to the fluid bath are not the same. The result is that the relative rates of oxidation of the phosphorus and carbon are different in the two cases, although in either case, with a given method of working, there must be a ratio between the phosphorus and carbon in which they disappear simultaneously. The industrial bearing of the question is very remarkable. In the basic Bessemer process the tendency of the phosphorus to linger in the bath renders an "after blow" necessary, it may be only of a few seconds' duration, but much iron is, nevertheless, burned and wasted, and Mr. Gilchrist tells me that if this after blow could be avoided, a sav-

ing of some six per cent. of the yield of steel would be effected annually, the value of which, at the present rate of output and price of steel, is no less than a quarter of a million sterling.

The volatilization of sulphur in the converter while it is retained by the steel in the open hearth furnace, and the increase in the percentage of manganese, which leaves the slag and returns to the bath of metal in the converter at the end of the "blow," will probably be traced to the disturbance of equilibrium which attends very slight variations in the conditions, especially as regards temperature and pressure, under which the operations are conducted.

In the blast furnace the reducing action must be greatly dependent on the rate at which alkaline cyanides are formed, and Hempel has recently shown, by the aid of well devised experiments, that the quantity of cyanides which may be obtained at a high temperature from carbon, nitrogen, and alkaline oxides increases as the pressure becomes greater.

Metallurgical chemistry is, in fact, a special branch of chemical science which does not come within the ordinary sphere of the academic teaching of chemistry. It is often urged that metallurgical practice depends upon the application of chemical principles which are well taught in every large center of instruction in this country, but a long series of chemical reactions exist which are of vital importance to the metallurgist, though they are not set forth in any British manual of chemistry, nor are dealt with in courses of purely chemical lectures. I feel bound to insist upon this point, because, as examiner in metallurgy for the science and art department, I find that purely analytical and laboratory methods are so often given in the belief that they are applicable to processes conducted on a large scale, and at high temperatures.

We are told that technical instruction should be kept apart from scientific education, which consists in preparing the student to apply the results of past experience in dealing with entirely new sets of conditions; but it can be shown that there is a whole side of metallurgical teaching which is truly educational, and leads students to acquire the habit of scientific thought as surely as the investigation of any other branch of knowledge.

It is, in fact, hardly possible, in a course of theoretical chemistry, to devote much attention to specific cases of industrial practice in which reactions are incomplete, because they are limited by the presence of bodies that cannot be directly eliminated from the chemical system. Take, for instance, the long series of reactions studied by Plattner, who published the results of his investigations in his celebrated treatise, "Die Metallurgische Rostprozesse," Freiberg, 1856, whose work I have chosen as a starting point on account of our presence in South Wales near the great copper smelting district of Swansea. A complex sulphide, of which copper is the main metallic constituent, contains some fifty ounces of silver to the ton. The problem may be supposed, for the present, to be limited to the extraction of the precious metal from the mass in which it is hidden, and the student deriving his knowledge from an excellent modern chemical treatise would find the case thus stated:

"Ziervogel's process depends upon the fact that when argentiferous copper pyrites is roasted, the copper and iron sulphides are converted into insoluble oxides, while the silver is converted into a soluble sulphate, which is dissolved out by lixiviating the roasted ore with hot water, the silver being readily precipitated from this solution in the metallic state."

It is certain that if an observant, chemically trained student visited a silver extraction works, and possessed sufficient analytical skill to enable him to secure evidence as to the changes that occur, he would find a set of facts which his training had not enabled him to predict, and he would establish the existence of a set of reactions to the nature of which his chemical reading had hardly given him a clew. The process to be considered is a simple one, but it is typical, and applies to a large proportion of the 7,000,000 ounces of silver annually obtained in the world from cupriferous compounds. He would be confronted with a ton or more of finely divided material spread in a thin layer over the bed of a reverberatory furnace. Suppose the material is what is known as a complex regulus as imported into Swansea or produced at Freiberg, to which are added rich native sulphides. The mixture then consists of sulphides mainly of iron and copper, with some sulphide of lead, and contains fifty or sixty ounces of silver to the ton, and a few grains of gold. It may also contain small quantities of arsenic and antimony as arsenides, antimonides, and sulpho-salts, usually with copper as a base.

The temperature of the furnace in which the operation is to be performed is gradually raised, the atmosphere being an oxidizing one. The first effect of the elevation of the temperature is to distill off sulphur, reducing the sulphides to a lower stage of sulphurization. This sulphur burns in the furnace atmosphere to sulphurous anhydride (SO_2), and, coming in contact with the material undergoing oxidation, is converted into sulphuric anhydride (SO_3). It should be noted that the material of the brickwork does not intervene in the reactions, except by its presence as a hot porous mass, but its influence is, nevertheless, considerable. The roasting of these sulphides presents a good case for the study of chemical equilibrium. As soon as the sulphurous anhydride reaches a certain tension, the oxidation of the sulphide is arrested, even though an excess of oxygen be present, and the oxidation is not resumed until the action of the draught changes the conditions of the atmosphere of the furnace, when the lower sulphides remaining are slowly oxidized, the copper sulphide being converted into copper sulphate mainly by the intervention of the sulphuric anhydride formed as indicated. Probably by far the greater part of the iron sulphide only becomes sulphate for a very brief period, being decomposed into the oxides of iron, mainly ferric oxide, the sulphur passing off. Any silver sulphide that is present would have been converted into metallic silver at the outset, were it not for the simultaneous presence of other sulphides, notably those of copper and of iron, which enables the silver sulphide to become converted into sulphate. The lead sulphide is also converted into sulphate at this low temperature. The heat is now raised still further with a view to split up the sulphate of copper, the decomposition of which leaves oxide of copper. If, as in this case, the bases are weak, the sulphuric anhydride escapes mainly as such; but when the sulphates of stronger bases are decomposed, the sulphuric anhydride is to a great extent decomposed into a mixture of sulphurous anhydride and oxygen. The sulphuric anhydride, resulting from the decomposition of this copper sulphate, converts the silver into sulphate, and maintains it as such, just as, in turn, at a lower temperature, the copper itself had been maintained in the form of sulphate by the sulphuric anhydride eliminated from the iron sulphide. When only a little of the copper sulphate remains undecomposed, the silver sulphate begins to split up, and the furnace charge must, therefore, be immediately withdrawn, or the whole of the silver sulphate would be converted into metallic silver, partly by the direct action of heat alone, and partly by reactions such as those shown in the following equations:

$$Ag_2SO_4+4Fe_3O_4=2Ag+6Fe_2O_3+SO_2$$
$$Ag_2SO_4+Cu_2O=2Ag+CuSO_4+CuO$$

If the charge were not withdrawn, the silver would thus be effectually removed from the solvent action of water, and the smelter's efforts would have failed entirely. The charge still contains lead sulphate, which cannot be completely decomposed at any temperature attainable in the roasting furnace, except in the presence of silica, and it is well to leave it where it is if the residue has subsequently to be smelted with a view to the extraction of the gold. The elimination of arsenic and antimony gives rise to problems of much interest, and again confronts the smelter with a case of chemical equilibrium. For the sake of brevity it will be well for the present to limit the consideration to the removal of antimony, which may be supposed to be present as sulphide. Some sulphide of antimony is distilled off, but this is not its only mode of escape. An attempt to remove antimony by rapid oxidation would be attended with the danger of converting it into insoluble antimoniates of the metals present in the charge. In the early stages of the roasting it is, therefore, necessary to employ a very low temperature, and the presence of steam is found to be useful as a source of hydrogen, which removes sulphur as hydrogen sulphide, the gas being freely evolved. The reaction—

$$Sb_2S_3+3H_2=3H_2S+2Sb$$

between hydrogen and sulphide of antimony is, however, endothermic, and could not, therefore, take place without the aid which is afforded by external heat. The facts appear to be as follows: Sulphide of antimony, when heated, dissociates, and the tension of the sulphur vapor would produce a state of equilibrium if the sulphur thus liberated were not seized by the hydrogen and removed from the system. The equilibrium is thus destroyed and fresh sulphide is dissociated. The general result being that the equilibrium of the system is continually restored and destroyed until the sulphide is decomposed. The antimony combines with oxygen and escapes as volatile oxide, as does also the arsenic, a portion of which is volatilized as sulphide.

The main object of the process which has been considered is the formation of soluble sulphate of silver. If arsenic and antimony have not been eliminated, their presence at the end of the operation would be specially inconvenient, as they give rise to the formation of arseniate and antimoniate of silver, insoluble in water, which may necessitate the treatment of the residues by an entirely different process from that which has hitherto been considered.

It will have been evident that effecting this series of changes demands the exercise of the utmost skill, care, and patience. The operations beginning at a dull red heat, or a temperature of some 500 deg., are completed at 700 deg., within a range, that is, of 200 deg. Judicious stirring has been necessary to prevent the formation of crusts of sulphates, which would impede the reactions, and, as has been shown, an undue elevation of temperature within a very limited range would, at any stage, have been fatal to the success of the operation. It is difficult to appreciate too highly the delicacy of sight and touch which enables an operator to judge by the aid of rough tests, but mainly from the tint of the streak revealed when the mass is rabbled, whether any particular stage has or has not been reached, and it will be obvious that the requisite skill is acquired solely by observation and experiment. The technical instructor may impart information as to the routine to be followed and the appearances to be observed, but scientific knowledge of a high order can alone enable the operator to contend with the disturbing influences introduced by the presence of unexpected elements or by untoward variations in temperature. In the training of a metallurgist it is impossible to separate education from instruction, and the above description of a very ordinary operation will show the intimate relations between science and practice which are characteristic of metallurgical operations. Practice is dependent on science for its advancement, but scientific workers too often hesitate to attack the metallurgical problems, and to devote the resources of modern investigation to their solution, because they are not aware of the great interest of the physical and chemical problems which are connected with many very simple metallurgical processes, especially with those that are conducted at high temperatures.

Proceeding yet one step farther, suppose that the copper smelter takes possession of the residual mass, consisting mainly of oxide of copper, he would smelt it with fresh sulphide ores, and obtain, as a slag from the earthy matters of the ores, a ferrous silicate containing some small proportion of copper. The displacement of the copper from this silicate may be effected by fusing it with sulphide of iron, a fusible sulphide of iron and copper being formed which readily separates from the slag. By this reaction some twenty thousand tons of copper are added to the world's annual production.

Proceeding a step farther, suppose the smelter to have reduced his copper to the metallic state. If arsenic had been originally present in the ore, and had not been eliminated entirely in the roasting, extraordinary difficulties will be met with in the later stages of the process, in extracting small quantities of arsenic which resist the smelter's efforts. Copper, moreover, containing arsenic cannot be "overpoled," as the presence of arsenic hinders the reducing action of gases on the copper. The amount of arsenic which the copper smelter has to remove may vary from mere traces up to one per cent., and if the copper is destined for the use of the electrical engineer, he will insist on its being as pure as possible, for the presence of a trace of arsenic would materially increase the electrical resistance of the copper, and would be fatal to its use in submarine telegraphy.

If, on the other hand, the copper is intended for the maker of locomotive fire boxes, he will encourage the retention of small quantities of arsenic, as it is found to actually increase the endurance of the copper, and the smelter will in such a case have no inducement to employ the basic furnace lining which Mr. Gilchrist has offered him, nor will he care to use the special methods for the removal of arsenic with which he is familiar. It may all seem simple enough, but the modern process of copper smelting has been laboriously built up, and has a long and interesting pedigree which may be traced to at least the eighth century, when Geber described the regulus "coarse metal" as being "black mixed with livid," and our familiar "blue metal" as being "of a most clean and pleasant violet color," and indicated the reasons for the difference.

(To be continued.)

THE SMOKE ANNIHILATOR.

Among the numerous methods which have been devised for the purpose of consuming smoke, the application of furnaces of special form has not been overlooked.

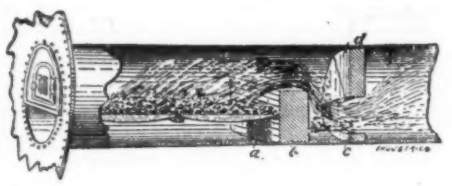
Mechanical stokers, forced draught, specially designed fire bridges, have all been pressed into service, in the attempt to solve the problem of how to prevent smoke.

Several furnaces have been at different times invented for the purpose of obviating this evil, and the system employed by the Gaseous and Liquid Fuel Supply Company (Limited), although not characterized by any striking feature of originality, nevertheless embodies a sound and scientific principle, and judging by the results obtained at recent trials, the smoke annihilator appears to be effective in its action.

The main object which it has in view is to furnish a secondary supply of heated air, which is introduced at the back of the fire bridge. As we previously mentioned, there is nothing new in this idea, but, up to now, it has been practically impossible to effect this without interfering with draught on the grate.

The fact of having overcome this difficulty, thereby rendering the secondary air supply available, without affecting the efficiency of the boiler, constitutes the chief feature in this system, thus converting a well known theoretical desideratum into a practical possibility.

As will be seen in our sketch, the air, after passing under the fire grate, goes through an opening at the bottom of the fire bridge (*b*), and coming into contact with the carbon monoxide and hydrocarbons which



have escaped combustion, consumes these gases, rendering them useful by utilizing the heat produced in their combustion. It will also be noticed that there is a drop arch (*d*) placed at the point where the heated air supply enters, which arch, becoming incandescent in consequence of the combustion of the carbon monoxide, etc., maintains the temperature necessary for the secondary ignition. That the combustion is achieved in a satisfactory manner, the following analyses will show.

The coal which was employed was exceptionally high in hydrocarbons, thus rendering the test a rigorous one. It gave upon analysis:

Fixed carbon	54·22
Volatile matters, chiefly hydrocarbon, with some sulphur	28·35
Moisture	4·70
Ash	12·73
	100·00

Upon testing the residual gases which were obtained by taking a sample over a period of two hours from the boiler flue, the following results were obtained:

Nitrogen	83·47
Oxygen	0·69
Carbon dioxide	15·01
Carbon monoxide	0·83
Sulphur dioxide, Free hydrogen and hydrocarbons	Absent.
	100·00

It thus appears that the whole of the hydrocarbons were removed by complete combustion, and the carbon monoxide present practically so, there being less than 1 per cent. present.

One great advantage in this system is that the regulation of the air supply is perfectly automatic, so that no extra trouble or responsibility is put upon the stoker, and, as naturally follows, it is admirably adapted for use where mechanical stokers are employed. This automatic regulation is effected by the gauze (*a*) which is inserted in the air passage, just before it passes the fire bridge, on its way to the secondary combustion chamber (*c*).

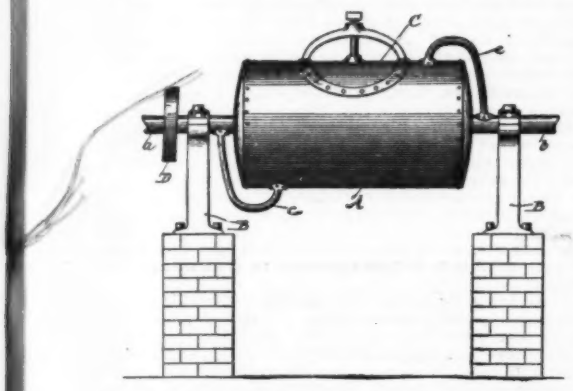
That an economy is effected by thus obtaining more perfect combustion, is proved by the fact that the hydrocarbons, usually allowed to escape unburnt, contain three-tenths of the heat of the original fuel, besides rendering the "economizers" more efficient by preventing the formation of sooty deposits upon the tubes.—*Chem. Tr. Jour.*

SYNTHESIS OF AMMONIA.

IT was demonstrated long ago, by Bunsen and Playfair, that when charcoal and potassium carbonate are heated to redness in an atmosphere of nitrogen, a certain quantity of cyanide of potassium is formed. Since that time Margueritte and Sourdeval have further shown that barium carbonate may be used instead of the potash, and that the barium cyanide produced may be again decomposed by steam into ammonia and barium carbonate. Theoretically, these reactions afford a continuous process for the conversion of atmospheric nitrogen into ammonia—a process which, if it could only be worked on a large scale commercially, would doubtless be of immense value. Unfortunately, only small proportions of the substances employed appear to enter into the reaction at ordinary pressures; hence the yield is insufficient to render the process economical. Professor Hempel has now shown by means of a simple pressure apparatus that the reaction is very much more complete, and, when potash is used, very energetic, under a pressure attaining sixty atmospheres. His apparatus consists of a solid steel cylinder closed at one end, and stopped with a screw at the other. A connection is made by a pipe from a pressure pump, and a carbon electrode also enters, and is plunged into a mixture of carbon and the alkaline oxide or carbonate. The electrode is made red hot, and nitrogen is forced in until the desired pressure is obtained. This process is not, of course, commercial, but it indicates an advance in the actual synthesis of ammonia compounds.

RECOVERING TIN FROM WASTE TIN-PLATE.

JEAN M. G. BONNET, of Paris, uses a cylinder, A, mounted upon trunnions, *a* and *b*, supported in suitable bearings upon the framework, B. The cylinder is provided with a charging or loading orifice, C, which is closed by means of a man-head. The trunnions, *a* and *b*, are tubular. The trunnion, *a*, is connected with the cylinder, A, by a pipe, *c*, and the trunnion, *b*, is connected with the cylinder, A, by a pipe, *e*. The scrap or waste tin-plate is placed in the cylinder, A, and the orifice, C, is closed. An alkaline solution, preferably caustic soda, is then run into the cylinder, A, at a temperature of about 250 deg. F. through one of the trunnions, *a* or *b*. Air previously heated to the temperature of about 250 deg. F. is then



forced into the solution in the cylinder, A. Agitate the mass for a short time, by rotating the cylinder by means of the pulley, D, on one of the trunnions. During this time the alkaline solution and the oxygen from the air will act upon the tin, forming stannate of soda, which remains in solution, while the iron of the tin-plate remains free of tin in the bottom of the cylinder. Then draw the solution from the cylinder, A, and separate the tin by introducing into the solution sulphurous acid, which precipitates the tin in the form of stannic acid, leaving sulphite of soda in solution. When the scraps of tin-plate are varnished, the varnish may be cleaned off by the use of sodium carbonate.

The same process is applicable in recovering lead from plate metal, the lead forming plumbates, which can be treated in a similar manner.

The chief point of the process is the use of hot air in the presence of an alkali to act upon tin, forming stannates. Other alkalies may be used, such as potassium hydrate; but caustic soda is preferable.

THE DISTILLATION OF MOLASSES.*

By Prof. T. P. HUTCHINSON.

IN discussing the distillation of molasses in Louisiana, the question of importance is, will it pay? In attempting to answer the question, our calculations must be largely based upon theory, for we have but little or no experimental data by which to be guided. True, other States in the Union have molasses distilleries, but I do not consider the results of the work done in these to be a fair guide. The results obtained in West India distilleries come much nearer to what might be expected from theoretical calculations.

The sugar planter of Louisiana that contemplates the distillation of his molasses first wishes to know how much rum or proof-spirit can be obtained from this molasses. I have made a careful examination of the chemical analyses of the molasses produced in some of the most skillfully conducted sugar houses in the State, such as Calumet, Even Hall and others. These molasses are found to contain from 55 per cent. to 65 per cent. of sucrose and glucose combined. During the months of January and February last, there were made in the chemical laboratory of the Louisiana Sugar Experimental Station, at Audubon Park, analyses of fifty samples of sirups and molasses. These samples were collected from the levee and from the retail groceries in various parts of the city of New Orleans. Of these fifty samples only twenty could be classed as Louisiana centrifugal molasses. These twenty samples showed by double polarization an average sucrose content of 39 per cent.

* A paper read by Prof. T. P. Hutchinson, before the meeting of the Sugar Planters' Association, September 12, 1891.—*La. Planter.*

The average glucose content was 26 per cent., making a total average of 65 per cent. sucrose and glucose. We can safely count on the average low grade, centrifugal molasses of Louisiana containing at least 60 per cent. of total sugars. Furthermore, Mr. Walter Maxwell, who, as chemist, is connected with the National Department of Agriculture, has recently made original investigations in the molasses from sorghum juice. Mr. Maxwell found that the carbohydrates, precipitated with alcohol from sorghum molasses, were entirely fermentable, and yielded their theoretical amount of absolute alcohol. The average low grade centrifugal molasses of Louisiana contains about 80 per cent. of total solids. As already stated, at least 60 per cent. of the molasses is sucrose and glucose, leaving 20 per cent. of solids, not ordinarily determined by Louisiana sugar chemists. Of this 20 per cent. of solids, we will say, from results obtained at Sugar Experiment Station, that from 10 per cent. to 12 per cent. consists of ash and nitrogenous bodies, leaving from 8 per cent. to 10 per cent. of solids that are probably fermentable. We are not prepared to say for certain that 8 per cent. or 10 per cent. of solids in Louisiana molasses is fermentable, but from Mr. Maxwell's investigations we have every reason to believe that with careful management they can be made to yield their theoretical amount of alcohol. However, in calculating the quantity of alcohol that can be obtained from Louisiana molasses, I shall use as a basis only the 60 per cent. of sucrose and glucose present.

A gallon of molasses having 80 per cent. of total solids will weigh about 11¾ pounds; 60 per cent. of the weight is about seven pounds. We have then in a gallon of molasses seven pounds of fermentable sugar.

The principal products of alcoholic fermentation are alcohol and carbon dioxide. Were these the only products, 51·11 per cent. of the sugar present would be converted into alcohol. But the higher homologues of alcohol are probably always produced, and according to Pasteur, such organic compounds as succinic acid and glycerine are formed. From 3 per cent. to 4 per cent. of the sugar present is consumed in forming these bodies, so that instead of 51·11 per cent. of alcohol being formed we shall count on about 49 per cent. Forty-nine per cent. of seven pounds is 3·43 pounds, showing that a gallon of molasses containing 60 per cent. of total sugar will produce 3·43 pounds of absolute alcohol.

The Internal Revenue Law of the United States provides that proof spirit shall consist of a mixture of equal volumes of water and alcohol, the latter having a specific gravity of "seven thousand nine hundred and thirty-nine tens of thousands at 60 deg. F.," water at its maximum density being taken as the unit. This alcoholic liquor will have a specific gravity of 93,353 at 60 deg. F., water at its maximum density being taken as the unit, and will contain by weight 42·7 per cent. of absolute alcohol. A gallon of this spirit weighs 7·77 pounds; 42·7 per cent. of 7·77 pounds is 3·31 pounds. Thus we see that a gallon of proof spirit in the United States contains 3·31 pounds of absolute alcohol. As already shown a gallon of Louisiana molasses will yield 3·43 pounds of absolute alcohol, or more than a sufficient quantity to make a gallon of proof spirit.

It might be well at this point to show to the sugar planters of Louisiana how to calculate the amount of rum or proof spirit that can be obtained from a gallon of molasses. Let us take for an example a molasses containing the percentage of sugar found in the twenty samples already referred to. The 39 per cent. of sucrose must be expressed in terms of glucose, as this latter sugar is the only carbohydrate capable of undergoing direct alcoholic fermentation. Sucrose before becoming capable of alcoholic fermentation must be converted into a mixture of glucose sugars (dextrose and levulose) called waist sugar.

After the chemical change has taken place there is a larger amount of sugar present; 1·9 parts of sucrose yielding 2 parts of glucose. The 39 per cent. of sucrose then becomes after inversion 41 per cent. of glucose, and hence we have in the molasses under consideration 67 per cent. of fermentable sugar; 67 per cent. of 11¾ pounds is 7·87 pounds; 49 per cent. of 7·87 pounds is 3·85 pounds, showing that a gallon of such molasses would yield 3·85 pounds of absolute alcohol, or enough alcohol to make 1·16 gallons of proof spirit. There will be some alcohol lost in the process of manufacture, but the amount lost will depend upon the skillfulness of the work done.

The Louisiana *Planter* of August 1 has an editorial on the distillation of molasses. In this editorial it is shown that during the season of 1890–91 the average amount of proof spirits obtained in American molasses distilleries was $\frac{144}{1000}$ of a gallon for every gallon of molasses. As already stated, I do not consider this average to be a fair guide, for the yield would certainly be too low for our molasses. We are not assured of the fact that in these distilleries all the requirements necessary to complete alcoholic fermentation have been carried out. A sugar solution to ferment well should not be too concentrated, from 20 to 25 per cent. being the maximum amount of sugar that should be present. However, Takamini, a Japanese scientist, claims to have a process of fermentation by which a sugar solution containing 40 per cent. of sugar can be thoroughly fermented. The ferment used in this process is the nematode demalode of the rice plant, and is said to live in an alcoholic liquor containing 20 per cent. of alcohol. If this process could be adopted in the fermentation of Louisiana molasses, the dilution would not be so great as in the ordinary process of fermentation. Some substances containing the fermenting principle must be present in sufficient abundance. The sugar solution should be kept at a temperature of from 25 to 30 deg. (77 to 86 deg. F.), and the fermentation allowed to continue until all the sugar is transformed. If these observances are strictly carried out a gallon of Louisiana molasses should yield a gallon of proof spirit.

The planters of the West Indies are accustomed to expect a gallon of proof for every gallon of molasses used, and these molasses are alcoholic producing substances inferior to the Louisiana product.

It is well to remember that the distillate from molasses is rum, its peculiar odor being due to the presence of ethyl butyrate and formiati. Factitious rums are produced by adding to grain spirit butyric and acetic ethers or by adding butyric acid alone.

Having determined the amount of alcohol that can be obtained from Louisiana molasses, the next questions of importance are the cost of manufacture and the value of the manufactured product. I shall leave these questions for others to discuss.

WORMS IN LEAD PIPES.

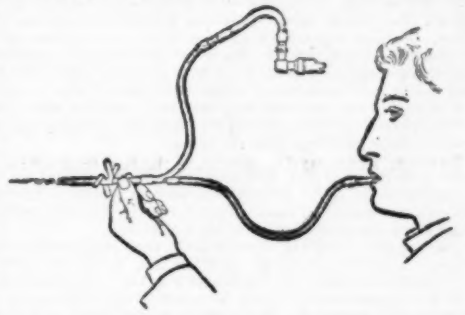
THE following communication by K. Hartmann, published in the *Gesundheits-Ingenieur*, purposes to draw the attention of technical men to the damages caused to lead work by the larva of a woodworm. Recently, when tracing the leaky places in a lead pipe, a live woodworm was found in one of the leaks, with its head protruding in the wall of the piping. The outer opening of the cavity was of oblong form, measuring 7 mm. by 4 mm., and the inner surface of the same showed fine indentures. Similar cases are not unknown and have occasionally found their way into literature. Thus it is mentioned in Kerl and Stohmann's "Handbook of Technical Chemistry" that certain woodworms (*Sirex gigas*) perforate sheet lead, the holes produced showing a rough surface with fine indentures. At the "Muldener Hutte" holes up to 6·5 mm. diameter were caused in sheet lead, the same being affixed to timber work. As the woodworm, which belongs to the family of the *Coleoptera*, works its way from the sap of the timber toward the bark, and from thence into the lead, it is proposed to so place the timber that the bark may be furthest removed from the lead.

Scheurer-Kestner (Compt. Rend. 53, 518) has published a case in which cylindrical holes were found in the lead lining of a beam of a new vitriol chamber, and this only a few days after effecting the covering. In one of the holes the semi-developed body of an insect was found, partly in the lead, and head first. The diameter of the perforation corresponded exactly to the body of the insect, so that the latter could not turn round in order to escape.

Similar observations having been made by others, the author does not doubt that in the case mentioned first the corrosion was caused by the woodworm.

IMPROVED BLOWPIPE.

THE time-honored Black's blowpipe, as usually supplied to chemical students, and generally employed in the chemical laboratory for the purpose of light work, and performing the various dry tests for detecting and confirming the metals, proved itself long since anything but convenient. In the first place, owing to its rigidity, it is impossible for the operator to move his



head without altering the flame, and, moreover, owing to the shortness of the stem, it often necessitates a stooping position. The blowpipe by Mr. C. G. Moor has been specially designed for the purpose of overcoming some of these difficulties.

For dentists, jewelers, and opticians, for hard soldering and brazing, this blowpipe will be found very useful; also for soft soldering as generally practiced.

One of the chief advantages which this blowpipe possesses is the facility with which it can be brought to bear upon any point at any angle. The control of the direction and the size of the flame can be regulated simultaneously, with the same hand. It is very simple in construction, well made, and, therefore, does not readily get out of order. The regulation of the flame is simplicity itself; while the India rubber tubes which connect the blowpipe with the mouth piece (which is made of glass) and with the gas supply give great freedom in use, and can readily be attached to an ordinary gas bracket.

On this account the blowpipe is very handy for teachers and the like, who have to travel, and have to take part of their apparatus with them.

As an adjunct to the laboratory, this blowpipe is most convenient. The inner and outer flame is very well defined, and, although a small blowpipe, it is, nevertheless, a powerful one for its size, the heat being sufficient to melt copper and silver; or, if hydrogen be employed instead of coal gas, even fine platinum wire can be melted.

For glass-blowing purposes, and in all cases where flames of varying size are required, the flame can be regulated to a nicety, while, although a good and reliable blowpipe, the price is sufficiently low to bring it within the reach of all.

SODA WOOD PULP.

THE following figures, which recently appeared in *Papier Zeitung*, will be interesting to our paper-making readers as exemplifying one of the many systems of manufacturing paper pulp from pine wood by what is known as the soda process. They embody results obtained by Mr. E. Hennefeld in a Swedish pulp works.

Sweden yields two varieties of timber suitable for paper pulp, namely, *Keifern* and *Fichte* (Swedish: *Fohre* and *Gran*). These two kinds correspond to *Pinus Sylvestris* and *Pinus Abies excelsa* respectively. They occur in tolerably equal quantities throughout the country. Trees having a diameter of 15 c. m. (about 6 inches) are not felled. The *Pinus Sylvestris* (Kiefer), after being cut, is sorted into three different sizes, viz., 15—25 c. m. dia., 25—35 c. m., and 35 c. m. and over. After the bark is removed from these poles they are cut into small pieces 12 mm. × 12 mm. × 4

mm. thick. In this state the wood is used for pulp boiling.

The pulp boilers hold 8½ cubic meters of chopped and cleaned wood, *i. e.*, 245 c. ft. of piled logs, and there are added to this quanity of wood 6 c. meters (6,000 liters) of caustic soda lye, containing 75 kilos. of soda (Na_2O) per cubic meter of wood. The pulp boilers rotate, their contents being heated by direct steam. The pressure employed is 125 lb. above atmosphere and the length of time this pressure is maintained is proportional to the age and variety of wood used. For example:

Timber of 35 c. meters dia. and above, the pressure is maintained for 2 hours.

Timber of 35—25 c. meters dia. and above, the pressure is maintained for 1½ hours.

Timber of 25—15 c. meters dia. and above, the pressure is maintained for 1 hour.

After this, the steam pressure within the pulp boiler is blown off, and the boiler emptied.

Each boiler full of wood yields 1,240 kilos. (24·35 cwts.) of air-dried pulp or 145·9 kilos. per c. meter of wood (35·28 c. ft.)

From these highly interesting figures we deduce the following:

60 per cent caustic required per ton of pulp 14·75 cwts.
Air-dried pulp per boiler..... .....24·35 "
Cubic feet of wood per ton pulp..... 245

HERMANN VON HELMHOLTZ.

By Hugo Kronecker.

Some thirty years ago the scientific visitor to Heidelberg could not fail to be interested in a large house, the "Riese," or giant, as it was termed, situated at the west end of the principal street of that town. The first floor of this house afforded shelter to the Physiological, the second to the Physical Institute. In the upper story of this house Kirchhoff and Bunsen compared the spectra of the metals with those of the sun; a few steps lower, Helmholtz built up the vowel sounds by combining the tones of vibrating tuning forks; Wilhelm Wundt, his then assistant, here taught us how graphically to record the contractions of the muscles, while the students, more inclined to play than to work, busied themselves with their prescribed practical exercises, which consisted in grinding teeth into slips of microscopic thinness.

When Helmholtz, our great master, walked through our work rooms, and the quiet but penetrating glance of his large, mobile eyes fixed itself on our insignificant work, we listened with strained attention to his instruction. In general, his directions were expressed in few words, yet these were sufficient to cause us to work for days, both with our heads and our hands. For, besides attending to the ideal conception of a research, he did not in the least neglect the practical working details. I remember how, during many weeks, he made me build up a myograph out of the boards of a cigar box, knitting needles, cork sealing wax, and glass plates, and his great head nodded friendly approval at this 'prentice work of mine.

To-day the whole world of learning celebrates his jubilee, and the German people, with just pride, congratulate their Helmholtz, and it appears becoming that we should cast a light over the path by which the great man reached his high position.

Hermann Ludwig Ferdinand von Helmholtz was born on August 31, 1821, at Potsdam, where his father occupied the position of a teacher in the "gymnasium." In his seventeenth year he entered the University of Berlin as a student. Helmholtz would have liked to have devoted himself to the study of physics. Circumstances, however, compelled him to enter on the study of medicine, a course which was rendered easy for him by the liberal arrangements of the Frederick William Institute, an institution for the training of military surgeons. The education which he there received he has never regretted. In his speech "On Thought in Medicine," delivered at the commemoration of the foundation of the Institute for the Education of Military Surgeons in Berlin, on August 2, 1877, he esteemed "that to have been a real happiness which he at one time had felt to be burdensome." He expressed himself thus: "Apart from the fact that I entered on the study of medicine at a period when any one who was even moderately skilled in physical modes of examination found a fruitful virgin soil to cultivate, I consider the study of medicine to have been the school which taught me, as no other could have done, the eternal laws which are the bases of all scientific work." The high conception which he entertained of the aims and objects of medicine may be gathered from the following quotation: "The prond saying of Hippocrates served almost as the watchword of the old deductive medicine *ἰητρὸς φιλόσοφος ἰσόθεος* (godlike is the physician who is a philosopher)." If we conceive the philosophical physician of Hippocrates to be a man possessed of consummate insight into the causal relations of the processes of nature, we shall be able to say of such a man that he will indeed be able to render aid even as a god might do. So understood, the sentence of Hippocrates expresses, in three words, the ideal which our science has to strive after. Who shall say wheeher it will ever be attained?"

Medical education, at the time when Helmholtz studied, depended still essentially on the study of books; microscopes were still dear and rare. "I myself," relates Helmholtz, "succeeded in becoming possessed of one by falling ill of typhus fever during the autumn holidays of 1841, when, being as a pupil gratuitously treated in the Charité, I found myself, on recovery, in possession of that part of my small income which had been accumulating during my illness. The instrument was not beautiful, yet by its aid I was able to recognize the nervous processes of the ganglion cells of invertebrates, which I described in my dissertation, as well as the vibrios referred to in my work on putrefaction and fermentation."

His inaugural thesis for the doctor's degree (November 11, 1842), the researches for which he undertook at the suggestion of the great Johannes Muller, afforded evidence of his intense power of observation, which always led him to discover the most important facts. This rare quality manifested itself likewise in the second work, already referred to, "On the Nature of Putrefaction and Fermentation" (1843). With all the strictness which the modern investigation of septic processes has been able to attain, did he demonstrate that putrefaction is not brought about, as Liebig had supposed, by the oxygen of the atmosphere, but that superheated air is entirely incapable of bringing about putrefaction or fermentation. In putrefying liquids he observed, with a magnifying power of 400 diameters, small spherules and large rod-shaped organisms, which moved slowly, and rotated around their long axes. Small pieces of boiled meat, inclosed in flasks, were likewise found by Helmholtz not to putrefy when he passed an electric current through the liquid, and, by the decomposition of water, set oxygen free. Schwann, his distinguished comrade in the laboratory of Johannes Muller, had already shown that vegetable cells bring about fermentations in solutions of sugar, which the introduction of superheated air was unable to induce. Helmholtz might, therefore, have considered his analogous observation as sufficient and complete in itself. But his scientific critical acumen, waging war against all sources of error, caused him to extend his observations. The extraordinary difficulties which these presented, at a time when many of our more valuable modern methods of investigation were not available, led to results which somewhat misled him. Surprised and doubtless disappointed by the conclusions to which his final experiments appeared to point, we find the youthful investigator (for he was still only 22 years of age) bowing modestly before the unwelcome truths of nature, and formulating his conclusions as follows: "From these researches it appears that putrefaction may originate independently of vital processes."* Thirty-nine years later he appended to the republication of this work ("Ges. Abhandl.," Vol. II., p. 737) the following remarks: "Recent researches make it probable that organisms of very minute size (which the extraordinary magnifying power, modes of illumination, and methods of staining of the present day have for the first time allowed us to recognize) are able to pass through or to grow through membranes." At that time Helmholtz occupied the post of military surgeon in Potsdam. But he remained faithful to his scientific mission. He contributed to the "Advances in Physics," published by the Physical Society of Berlin. The invitation to write the article on "Heat" in the Encyclopædic Dictionary of Medical Sciences gave him the

PROFESSOR VON HELMHOLTZ.

opportunity (1845) of writing an essay on this subject which, even to-day, may serve as a model. His thoughts turned in this paper to one of the most important physiological questions relating to the nature of vital power—whether the life of organisms be due to a peculiar self-producing purposeful power, or is the result of forces acting also in inorganic nature. He examined the material exchanges of muscular action, and found that the substances contained in muscle soluble in water were diminished in quantity by muscular activity, whereas those extracted by alcohol were increased in amount, so that "a chemical change occurs in compounds contained in it." He expected at that time that a deeper comprehension of these processes would result from further investigations; and yet to-day the highly developed state of physiological chemistry is unable to give a clearer answer to the question. In near relation to this, he proved (1847) that muscles give out heat during activity.

In the same year, in a small pamphlet on "The Conservation of Energy," he gave a vigorous proof of the following proposition: "In all cases of the motion of free material points under the influence of attracting and repelling forces whose intensity is solely dependent on the distance [the loss in potential energy is always equal to the gain in kinetic energy, and the gain in the former is equal to the loss of the latter, so that] the sum of the kinetic and potential energy is always constant." From this it follows that no energy is lost in the world, but that it alters only in its mode of manifestation, so that, for instance, chemical affinity can be converted into heat or electricity, this latter into heat or motion of masses, etc. At the same time, he showed that all the processes of nature obey the laws of mechanics.

Previously to this, heat had always been regarded as a "substance." Helmholtz showed that "the phenomena of heat can all be looked upon as motion." With this he brought science on to a plain path. But at first he met with opposition from authorities on the subject. His article was rejected by *Poggendorff's Annalen*, and among the members of the Berlin Academy only Jacobi, the mathematician, espoused his cause. Even when his fame penetrated through wide circles, doubt was thrown on the originality of this epoch-making work. Helmholtz had written his pamphlet in ignorance of the work of Robert Mayer (1842 and 1845). When still in the third form of the gymnasium of Potsdam, he had found it perplexing to reconcile the experiments of Rumford and Humphry Davy on the production of heat by friction with the then orthodox conception that heat was an imponderable substance. What wonder, then, that as a fully developed mathematician and physicist he should recognize that the "heat resulting from friction is to be looked upon as the apparently lost *vis viva*"?* Helmholtz readily acknowledged the priority of Joule and R. Mayer even before it was claimed, and was the first to bring into prominence the merits of the doctor of Heilbronn in the discovery of the great new universal principle.

But how far above his predecessors he was! R. Mayer's first essay gives no *proofs*, but only sets forth theses, and even in his more detailed article on "Organic Motion in its Relation to Metabolism" (1845) he supports only by general, although extremely ingenious, arguments his axiom that "in all physical and chemical processes the given energy remains a constant magnitude" (p. 32); and further, "in vital processes there is only a transformation of matter as well as energy, but never any creation of either the one or the other" (p. 40). Mayer, too, on even the most suitable occasions, does not mention his immediate predecessor Joule. In how different manner do the trained physicist and speculative doctor treat the same subject! Helmholtz proved experimentally the increased consumption and increase of heat during muscular activity. Mayer affirmed—without proofs—that every casual movement took place with the formation of carbonic acid and water; that "every muscle whose supply of atmospheric air is cut off ceases from its activity"† (p. 87). "With every muscular action, heat *in statu nascente* is set free" (p. 94). "In continued work there is a summation of this loss of heat which can be detected by observation" (p. 95). "A clever smith can bring a cold piece of iron to red heat by hammering; but this temperature is made at the expense of the temperature of his arm. *Ex nihilo nihil fit*" (p. 96).

Helmholtz calmly followed his own lofty path, as teacher of anatomy in the Academy of Art in Berlin, and assistant in the anatomical museum; he succeeded one of his friends occupied in the same pursuits, namely, Brucke, and found another, E. Du Bois Reymond, still with his teacher, Johannes Muller. In the following year, Helmholtz was called to Konigsberg as professor of physiology and general pathology. "General pathology was looked upon by the ancients as the finest flower of medical science. But what formerly made up its contents has only historical interest for the disciple of modern science." It was on dogmas that the fundamental views of medicine were then based. Helmholtz was always an enemy of the deductive method. "The fact of a conclusion being drawn by the most accurate and logical methods from an uncertain premiss does not add a hair's breadth to its certainty or value." Many old physiologists considered it beneath their dignity to make experiments, but Helmholtz always maintained, in contradiction to the metaphysicians, that "it is the duty of scientific research to seek the laws governing disconnected facts." How fruitful were his methods is shown by his researches at Konigsberg, in the first of which, in 1850, he determined the duration of muscular contraction and the rate of transmission of nervous impulses.

The problems which v. Helmholtz attacked when he applied delicate physical methods to the investigation of the time relations of muscular contraction and of nervous acts are so full of interest as to merit a passing notice, even in so brief a summary as that we are able to give.

"A moment" is the popular expression for an immeasurably short space of time. v. Helmholtz showed that the muscular contraction which physiologists designate "a simple muscular contraction," and which the non-scientific person would pronounce an instantaneous act, lasts about one-tenth of a second, and is, therefore, more than one thousand times as long as a flash of lightning. "Quick as thought" expresses the popular conception of inconceivable speed. The older physiologists shared the popular idea. Thus we find Johannes Muller stating in the last edition of his text book (1844, Vol. I., p. 551): "Stimuli act instantaneously throughout the whole length of the nerves, and throughout all their fibers, irrespective of the point of stimulation." Basing his opinion on the researches of Du Bois Reymond, Johannes Muller inclined to the opinion that nervous force and electricity were identical. As early as 1845, Du Bois Reymond had worked out the plan of estimating the speed of muscular and nervous activity by the method which Pouillet had devised for measuring exceedingly short intervals of time. He, however, had hesitated to carry out this plan, fearing much that this method of research would not be applicable for measuring such great velocities through such short paths. Five years later v. Helmholtz, by means of Pouillet's method, as well as by a graphic method, estimated the mean rate of transmission of nervous activity in the motor nerves of the frog, and found it to be 26·4 meters per second, or less than ten times slower than the velocity of sound in air, or about equal to the rate of an English express train. In the course of these researches, he enriched physiological experimental methods by his myographion.

In the very next year (1851) v. Helmholtz astounded the scientific world by his discovery and description of the ophthalmoscope, for examining the retina in the living eye, "an optical instrument, by the aid of which it is possible to see exactly, and to recognize, in the living eye, the retina itself and the images of luminous objects thrown on it." By this discovery v. Helmholtz raised ophthalmic medicine to the position of a scientific study, and made it possible to save the eyesight of thousands of human beings. This magnificent discovery, too, was not due to direct inspiration. Already, in 1847, Cuming and Brucke had explained the conditions under which the interior of the eye appears luminous, and a Bernese doctor, von Erlach, had succeeded in illuminating the fundus of the eye by means of his spectacle glasses. But it is just the characteristic of the far-seeing intellect of v. Helmholtz that it recognizes the importance of things which even men of the caliber of a Du Bois Reymond or a Brucke pass by, with open eyes. In this respect he resembles Theodor Schwann, his celebrated predecessor with Johannes Muller; he surpassed Schwann, however, in his thoroughness, which led him always to test his

* Lectures and Speeches. Vol. i., p. 66.

† Johannes Muller confirmed (1833–1837) already in the older editions of his celebrated text book the observations of Spallanzani that cold-blooded animals continue to expire carbonic acid even in an atmosphere free from oxygen. Burdach says the same of warm-blooded animals in his "Physiology" (1835), vol. v., p. 375.

work, "and not to leave it until it is impossible to improve upon it. It is work of this kind, which, by the classic completeness of its methods, and by the accuracy and reliability of its results, deserves and obtains the best and most lasting fame."*

It was by work of this kind that v. Helmholtz worked out and elaborated physiological optics, in the first instance discovering the nature of the act of accommodation by the employment of new methods, and especially by the use of the ophthalmometer (1853). Afterward, when Professor of Anatomy and Physiology in Bonn (1855), he investigated the composition and action of the spectral colors. Ten laborious years be devoted, mostly, to his "Text Book of Physiological Optics" (1856–1866). In this work he made it "his duty to test and verify all essential points by his own observations and experiments." Thus, this work has become, as it were, a Bible to both the physiologist and the ophthalmic surgeon.

The great men who at that time, together with v. Helmholtz, laid the foundation of the modern German Physiological School, E. H. Weber, C. Ludwig, E. du Bois Reymond, and Brucke, had obtained for this science an independent position. It had come to be recognized that physiology must be separated from anatomy, and Du Bois Reymond had avowedly claimed for it the proud aim of ultimately merging into physics and chemistry. The new Chair of Physiology in the University of Heidelberg was offered to v. Helmholtz, and accepted by him. It was in Heidelberg that he displayed a new aspect of his high genius. He there produced his work entitled "The Doctrine of Tone Sensations as a Physiological Basis of the Theory of Music." "Music," said v. Helmholtz, "stands in a much nearer relation to pure *sensations* than any of the other arts, which have rather to do with *perception*—that is, with the conceptions of external objects—these being the results of psychical processes originating in sensations." Poetry obtains assistance only in a minor degree from music, *e. g.*, in its rhythm, "but tone painting depends directly on the sensory endowment of the ear." "In painting, color is an element which is directly taken up by sensory perception." "The artistic pleasure given by a marble statue does not arise from the sensation of the white light which it sends into the eye, but rather from the conception of the beautifully formed human body which it represents." "Tones and tone sensations act quite independently of their relation to any external objects."

Pythagoras was well acquainted, from the ancient teachings of the Egyptian priests, that harmony—"the perfect consonance"—is produced when strings whose lengths (material and tension being the same) are in the ratio 1:2, or 2:3, or 3:4 are sounded together. They then sound the octave, fifth, or fourth. Nowadays, measurement is not expressed in terms of the length of strings, but of the number of vibrations, and by this means the laws of harmony can be tested on all musical instruments. To these consonances have been added the major and minor third (4:5 and 5:6). But what has pleasurable sensation to do with simple numerical ratios? Does a foot rule give us any pleasure? V. Helmholtz had already put forth the fundamental ideas of his theory in popular form in 1857, in a lecture he gave at Bonn "On the Physiological Causes of Musical Harmony." His sequence of ideas was essentially as follows: The ear separates those wave forms which flow to it, if not already simple (*e. g.*, the note of a tuning fork), into a number of simple waves, and feels these separately as simple notes, and does this whether the wave originated as such from the source of sound, or was compounded on the way. It is the grooved basilar membrane in the cochlea, an organ comparable to a harp in structure, which gives the ear the capability of doing this with the greatest accuracy and certainty. If a mixed note hits them, all those string-like portions of the membrane whose individual parts correspond in vibration number to the single tones in the note are thrown into vibration, just as a number of strings in a piano (with the dampers off) vibrate if a vowel is spoken into it. Besides the fundamental tone, the overtones are also heard.

The vibrations of two notes, but slightly different in pitch, strengthen and weaken each other periodically; we hear waverings, beats, grating; rough dissonance. In a similar manner, but not so markedly, neighboring overtones interfere with each other. "Harmony and discord differ in this: in the first the tones flow away easily, each by itself, while in discord disturbances occur, and the tones are divided up and collide with each other." "Artistic instinct unconsciously discovers the nature of the artistically beautiful." In a word, v. Helmholtz discovered the hidden law which governs the musical character of harmonic tone combinations. In the course of these researches, he thoroughly traced out the mechanism of the auditory ossicles (1867 and 1869) and enriched philology with the theory of the formation of vowels. He showed that the principal difference between vowel sounds and those of most musical instruments is that the strength of their overtones depends not only on their serial number, but chiefly on their absolute pitch, and that the various vowels are distinguished by the difference in the strength of their overtones. By altering the length, width, and form of the cavity of the mouth, the speaker is able to give the strength to the dominant overtones which characterize the vowels he desires to utter.

Besides the physiological researches which have been briefly referred to, v. Helmholtz turned his attention to others closely connected with them. In optics he developed our knowledge of the horopter; in muscle physiology he investigated the muscular sound, and he added to the physiology of nerves by extending the researches which he had made on the rate of transmission of impulses in the nerves of the frog to the motor nerves of man. Moreover, in conjunction with his pupils, he now attacked problems of the highest interest to psychology, problems which had obtruded themselves on his attention in the course of his investigations on light and sound. Thus he measured, by strict physical methods, the time required for the perception of the effects of external stimuli, as well as the time occupied in the simplest mental processes.

The interest which v. Helmholtz manifests in branches of philosophy other than psychology is shown by the scientific scrutiny to which he subjected the axioms of geometry ("Collected Essays," Vol. II., p. 610; "Letters," Vol. II., p. 1). In the course of his researches on the representation in space of the system of colors, as well as on the origin of the power which the eye possesses of estimating magnitude, he had arrived at the conclusion that the axioms of geometry possess no *a priori* significance. As is matter of common knowledge, certain of these axioms assert that (1) a straight line is the shortest path between two points; (2) a plane can be drawn through any three points in space which do not lie in the same straight line; (3) two lines are termed parallel if, lying in the same plane, they never intersect; (4) through a point outside a given straight line but one line can be drawn parallel to the given line. Besides these, geometrical axioms give expression to statements determining the number of dimensions of space, its surfaces, lines and points, and explanatory of the idea of continuity, *e. g.*, the boundaries of a body are its surfaces, of a surface a line, of a line a point, and a point is indivisible. Further that by the motion of a point a line is described, by the motion of a line a line or surface, by that of a surface a surface or solid, but by that of a solid only a solid. All this is unproved and did not seem to need proof as long as the only method of geometry was that of Euclid and his followers ("Lectures," Vol. II., p. 6). But if dimensions of another kind than the Euclidian are imaginable to the mathematical mind, this would be "proof that geometrical axioms are not necessarily conclusions from an *a priori* transcendental form of conception in Kant's sense of the word" (p. 22). "Every comparison of size, be it estimation or measurement of relations in space, starts from an assumption regarding the physical properties of certain natural bodies, be it of our own forms or of the measuring instruments employed; and, although this assumption is exceedingly probable, and is entirely in concord with all that is known of physical properties, it certainly goes beyond the region of pure conceptions of space." "So that geometrical axioms make assertions, not merely in regard to the properties of space, but also in regard to the mechanical behavior of the most rigid bodies during motion" (p. 29). "These are facts attained by accumulated experience, like many propositions which have seemed to metaphysicians to be of *a priori* nature." Here, as throughout all his studies, we find v. Helmholtz endeavoring to trace the original cause of phenomena. In the case of the complicated processes of life, with which physiology deals, this is difficult, and generally impossible. It was but natural that the intellectual tendencies of the exact investigator should dispose him to accept the Chair of Physics in the University of Berlin, which had just become vacant by the death of Magnus (1871). From this time forward he was engaged chiefly in inquiries in the great departments of electricity and hydrodynamics. The attempt had been made by celebrated physicists and mathematicians, like W. Weber, Riemann, and Clausius, "to explain electrodynamic phenomena by the assumption of forces acting at a distance between two portions of the hypothetical electrical fluid, the intensity being dependent not alone on the distance but also on the velocity and acceleration."* The general mathematical formula of "the law of potential" for the strength of induced currents had been deduced from Ampere's law by the Nestor of Konigsberg, F. E. Neumann.

At the time of its discovery, Newton put forth his great law of gravitation, which was to hold together the solar system, with hesitation and diffidence. The idea of forces acting in the absence of intermediate points of action, although then so daring, seems now self-evident. Faraday again raised the discussion on the problem whether forces exist acting at a distance without an intervening medium, by his remarkable discoveries of the phenomena of induction, rotation of the plane of polarization by magnetization, dielectric polarization of insulators, and of diamagnetism. He concluded that every portion of space through which the magnetic force acts is in a permanently altered condition, in a state of tension which tends to return to its original condition as soon as the magnetic influence ceases, and that every alteration in this condition is manifested by the appearance of electromotive forces. Maxwell worked out the new theory mathematically and showed the possibility of regarding electricity, magnetism, and light as merely different states and motions of the same medium (the ether).

The aim of v. Helmholtz in this direction "had been to determine in what direction experiments should be made to decide between the various theories. He succeeded in making such an experiment on the electricity collected on the surface of a conductor rotating in the magnetic field. This experiment decided in Faraday's favor."† The second great problem whose elucidation Faraday had in mind, namely, the relation between electrical and chemical forces, stimulated v. Helmholtz to a series of important investigations. He formulated Faraday's law in this way: "Through every cross section of an electrical conductor there is always equivalent electrical and chemical motion' (*loc. cit.* 295). He then investigated this motion and the forces expended on it. He was able by means of the mechanical theory of heat to calculate (in the case of a solution of salt) the effect of the water on the electromotive force. In this way he came to the investigation of the thermodynamics of chemical process and solved the general problem—what portion of the energy present in any system can be transformed into another kind.‡ He arrived at the result that all chemical compounds below their dissociative temperature give off heat, if produced in the reverse manner. In a highly ingenious manner he showed the reflex effects of the ether and ponderable atoms on each other, in his work on "The Theory of Abnormal Dispersion."§

Having in 1888 already shown the remarkable analogy of the vortex motions of water with the electromagnetic effects of electric currents,‖ he now applied the theory of friction of solid bodies to that of flowing extremely thin films of fluids, and thus created an analogy between electrodynamics and hydrodynamics (1879).* He also introduced the conception of "Electrical Convection," viz., "The Transmission of Electricity by the Movement of its Ponderable Conductors" (1876). He showed that the law of constancy of energy makes it possible,† without the aid of any hypothesis as to the internal constitution of electrically or magnetically polarized bodies, to find the effect of the pondero-motor forces acting on the interior of such bodies, and causing changes of form. The conclusion is that the hypothetical system, assumed by Faraday, of tensions acting along, and pressure at right angles to, the lines of force, actually exists and acts in such bodies.

In his studies on the statics of monocyclic systems ‡ he added to mechanics the new idea of "Kinematic connection" (where the kinetic energy is the integrating denominator), *e. g.*, between bodies of the same temperature, or two tops whose axes are so connected that they must preserve the same rate of rotation.

In another essay § v. Helmholtz thought the "principle of least action" was the general law governing all "reversible natural processes," and as regards the irreversible processes, *e. g.*, the production and conduction of heat, it appears that the irreversibility is not intrinsic, but depends more on our limited means of action, since these do not allow us to bring back displaced atomic motions to their initial condition, or to effect the exact reversal of all atoms engaged in thermal motion.

The motion of fluids had already interested v. Helmholtz greatly at the time of his first acoustical investigations. He had investigated theoretically the motions of vortices in 1858, and confirmed the results in a few simple cases by experiment. Dove had shown that the constant change of weather to which we are subject was due to reciprocal alterations of cool dry polar winds and warm damp equatorial winds. In a lecture given in 1875‖ on cyclones and thunderstorms, v. Helmholtz explained the mechanical relations of wind currents, one upon another. Later on he gave a mathematical investigation of atmospheric movements.¶ Starting from Euler's hydrodynamical differential equations, he came to the conclusion that the chief resistance to the circulation of the atmosphere lay not solely in its friction against the earth's surface, but rather in the mixing of different moving strata of air, leading to the formation of vortices. At the Cape d'Antibes he made observations on the energy of the waves and wind. The results obtained were that a wind lasting a considerable time gradually gives up some of the energy of its lower layers to the water. Wave systems of different length are thereby formed, and by their interaction (just like the formation of combination tones) stationary waves of greater length and velocity are formed. The wind can give up energy to the waves as long as its velocity is greater than theirs.

Lightning is explained in the above mentioned lecture somewhat as follows: The earth is permanently charged with (probably negative) electricity. Air and water vapor (not fog) are electrical non-conductors. Only when the clouds unite to form rain, and thus allow their water masses to come near enough together to allow of discharge from drop to drop, do they form one mighty conductor into which enormous sparks, lightning, can pass from the earth. The rain appears on the earth after the lightning, because it takes so much longer to fall than the time occupied by the electrical discharge. It is not at all impossible that a fire, or the thunder of the cannon in battle, should bring about a storm. If a state of unstable equilibrium already exists in the atmosphere, any circumstance which will cause the first small portion of the damp, warm mass of air to rise may act the part of a spark in a powder magazine, and direct the chief discharge to the spot of this primary disturbance. We cannot hope ever to be able to forecast the weather. For small primary errors do not produce simply small errors in the results, because the item of unstable equilibrium enters into the conditions.

Though we have only touched but briefly on some of the most important of the researches of our great master, our survey, as yet far from complete, will have convinced the reader that scarcely a region throughout the whole domain of nature has been left altogether unassailed by him; "wherever he attacks it he is interesting." The capacity to apply theoretical conceptions to practical uses is illustrated by his applying the discussion of a theorem on the geometrically similar movement of fluid bodies to the problem of steering the balloon.** That he still preserves a deep interest in the subject of one of the greatest works of his life is shown by his discovering, quite recently, while making experiments on his own eyes, that their fundi were themselves luminous, so that he was able to recognize the movement of his own arm in intense darkness.†† In the autumn of 1887 the German empire founded a physical-technical institution, Dr. Werner Siemens, the well known electrician, having given for the purpose a sum of one half million of marks (£25,000). The institute comprises two departments, one for purely scientific purposes, and the other concerned with the application of scientific physics to technical purposes. The first is a laboratory for the advancement of pure science. Such work as may be necessary for the advancement either of science or of technical pursuits, and which requires for its accomplishment specially fitted rooms, costly apparatus, and special talent, is to be done there. The second department has for its object to develop technical scientific methods and appliances, and to keep industry abreast of the progress of science. Over this great and important new institution, v. Helmholtz was chosen by the government to preside, while he was further appointed director of the first or purely scientific department. In consequence, he resigned the Chair of Physics and the directorship of the Physical Institute

* These words of praise v. Helmholtz applied to the great physicist Magnus, his predecessor in the chair which he afterward filled in the University of Berlin. (Speeches: Vol. II., p. 40.)

* "Lectures," Vol. II. p. 283.

† Lecture on Faraday's anniversary to the Chemical Society in London on April 5, 1881. ("Lectures," Vol. II., p. 283.)

‡ Ber. A. Berliner Akad. D. Wiss. 1882.

§ Ber. D. Berliner Akad. D. Wiss. 1884.

‖ "Collected Essays." Vol. I., p. 101.

* "Studies on electrical limiting layers." *Wied. Ann.*, Vol. II., p. 337.

† "On the internal forces of magnetized and dielectrically polarized bodies." Royal Soc. *Proc.*, XXXVI, 1887.

‡ Ber. D. Berliner Akad. D. Wiss. 1884.

§ Kronecker's and Weierstrass "Journal of Mathematics," Vol. C., p. 142.

‖ "Lectures." Vol. II., p. 141

¶ Ber. d. Berl. Akad. de Wiss. 1888, p. 647.

** "Collected Essays." Vol. I., p. 158, and Ber. E. Berl. Akad. 1873, p. 501.

†† "A. Koenigs. Zeitsur. f. Psychol. u. Physiol. d." Tinnes Organo, Bd. 1. § 1.

of Berlin, though he still retains the position of Professor ordinarius in the University, and delivers lectures on special subjects of theoretical physics. In 1883 the German Emperor conferred on Herr Helmholtz and on his family the honor of hereditary nobility.

To give an adequate account of the life and works of v. Helmholtz would require a large volume. The brief notice of those works which we have been enabled to give leads us, however, almost naturally to certain more general reflections concerning his genius, character, and life work.

One of the first reflections which occurs to one in relation to the scientific work of v. Helmholtz is that no problem has appeared to him impossible, and, at the same time, he has considered no technical detail insignificant or unimportant. His estimate of the value of popular exposition has been a high one, and he has not thought it beneath himself to lecture and write in a popular style. Even the readers of this sketch have had the opportunity of appreciating, from the quotations which it contains, the clear and beautiful manner in which he can explain difficult problems in mathematics, in physical science, or in philosophy. In connection with these popular expositions a reflection must force itself upon every one, capable of judging, in reference to one of the highest characteristics of v. Helmholtz as a popular teacher. He does not sink to the level of his audience, but he draws them up toward himself.

But in addition to science, the arts, and nature also, find a place in his great mind. Of music he is a friend full of understanding and devotion. Already in 1857, in the birthplace of Beethoven (Bonn), he praised the power of music in the following words: "In an artistic musical work the movement of sound follows the outflow of the artist's own emotions. Now gently gliding, now gracefully leaping, now violently stirred, penetrated, and laboriously contending with the natural expression, the stream of sound, in primitive vivacity, bears, even into the hearer's soul, unimagined moods which the artist had overheard from his own, and finally raising him to that repose of everlasting beauty of which God has allowed but a few of his elect favorites to be the heralds." After leading home, as his wife, to his stately official dwelling, the gifted daughter of the celebrated statesman Robert von Mohl, the hospitality of the honored couple was exercised in the noblest manner. The evening receptions brought together a great number of the most learned and accomplished men and women of Berlin, and were always rendered charming by the musical talents of the most celebrated artists. As admirers of Wagner, they often made a pilgrimage to Bayreuth during the representations there, and thence the great investigator loved to wend his way to the world of Alpine nature in the Engadine.

Accurate and close as is his mind in the pursuit of scientific truths, his sensitive nature expands at the sight of the higher regions of nature. In the introduction to his lecture on "Ice and Glaciers" he says: "While some content themselves with admiring from afar the dazzling adornment which the pure luminous masses of snowy peaks, interposed between the ocean blue of the sky and the softer green of the meadows, lend to the landscape, others more boldly penetrate into the strange world, willingly subjecting themselves to extreme degrees of exertion and danger, if only they may fill themselves with the aspect of its sublimity."

What a noble revelation of his inner self does he afford us in the toast in honor of the town of Heidelberg, which he proposed on the occasion of the fifth centenary of the foundation of the University of Heidelberg.

He would, he said, consider the beauty of the University town from the standpoint of the man of science. "Was it a mere accident that it was from these green hills that the mental eye of man for the first time penetrated the immeasurable world of space with the idea of how the chemical nature of the heavenly bodies might be deciphered—an undertaking which just before must have appeared an utter impossibility? I think the opposite. Something of a poet's intuition the investigator must have. Naturally, he must have care and patience to sift and prepare his material. But work alone cannot compel luminous ideas; these, like Minerva from the head of Jupiter, spring into being unexpected and unforeseen; we know not whence they come. This only is certain: To him who knows life only from books and paper, and who is tired and exhausted by the monotony of work, to him they come not. The consciousness of fullness of life and power must be present, such as comes from wandering in the pure air of the mountains. And when the wanderer, separated by the quiet peacefulness of the forest from the turmoil of the world, beholds, at one glance, spread before him, the rich plain, with the fields and villages, and the setting sun spinning golden threads over the distant hills, then arise in sympathy, in the dark background of his mind, the germs of new ideas, destined to bring light and power into the inner world of his imagination, where before there was chaos and darkness." Thus this great man, in the festive hours, allows us to catch a glimpse of the workings of his mind. But he who would appreciate the full stature of this ruling mind must climb the lower intellectual heights, and the greater the height he is able to attain, the more gigantic will the mountain seem above him. To-day the scientific men of both hemispheres unite to do honor to v. Helmholtz. A gold medal has been struck in his honor, which is to be annually awarded to the most worthy of his co-workers. Let the cultured of all classes hand the laurel crown to one of the noblest of men, cherishing the hope that his exalted intellect may long remain to enlighten us. *The Electrician.*

PROCESS OF MAKING CAUSTIC ALKALI.

By Francis Ellershausen, Hebburn on Tyne, Durham, England.

This invention relates to the manufacture of caustic soda from sulphide of sodium by means of ferrate of soda, sometimes called "ferrite of soda," and hereinafter referred to as "ferrate." It is known that if ferrate of soda be lixiviated with water, a solution of caustic soda is obtained and hydroxide of iron is deposited. It is also known that if a solution of sulphide of sodium be treated with hydroxide of iron (either in the natural state or produced as above described or in any other suitable manner), the said solution is causticized and sulphide of iron is formed. The equation which represents this reaction is probably as follows:

$$Fe_2(HO)_6+4Na_2S=Fe_2Na_2S_4+6NaOH$$

The chief drawbacks to the use of hydroxide of iron are its moist nature and its finely divided condition, which cause it, when in contact with the solution treated, to assume a muddy form, through which it is impossible for the liquid to percolate, so that there is very little contact between the solution and the hydroxide, and consequently an imperfect reaction. If, in order to obviate this imperfect reaction, the sulphide of sodium solution is agitated after the introduction of the hydroxide of iron, it is found that a large proportion of the soda goes with the sulphide of iron unless the solution is diluted to such an extent as to render the cost of concentration a bar to the commercial working of the process, and in addition to this the quantity of free water given off by the hydroxide of iron during the reaction tends still further to reduce the strength of the caustic solution. For these and other reasons such a process has not been commercially successful, although many attempts have been made to use it.

The chief object of this invention is to obviate the defects heretofore experienced in the direct use of hydroxide of iron in the manufacture of caustic soda from sulphide of sodium; and to this end I treat the sulphide of sodium with ferrate directly. I believe that the reaction which occurs may be expressed as follows:

$$Fe_2O_3Na_2O+4H_2O+4Na_2S=Fe_2Na_2S_4+8NaOH$$

The mode in which I prefer to conduct the process is as follows:

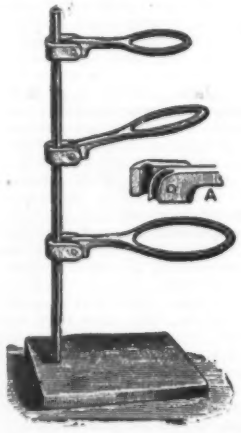
I roast carbonate of soda and peroxide of iron and obtain the ferrate in a granular form. The use of ferrate in the granular condition gives the best results. I form a filter bed of the ferrate, which may be of considerable thickness—say about four feet deep—into which the solution of sodium sulphide of a strength of say 40 deg. Tw. is poured, and through which, owing to the granular form of the ferrate, it can freely percolate. In the course of this percolation nearly all the soda in the ferrate and the sodium in the sulphide solution are converted into a solution of caustic soda, while another portion of the soda forms with the iron a double compound, videlicet, sulphuret of iron and sodium, which is insoluble. The strength of the said solution is considerably increased by the presence of the soda originally contained in the ferrate. By reason of the fact that ferrate is anhydrous, and in its conversion into caustic soda absorbs a considerable quantity of water from the solution, the concentration of the solution is considerably increased.

In practice the ferrate forming the filter bed is advantageously placed in a metal tank, and, in order to prevent the latter from being injured by the contact of the sulphide of sodium therewith, the sulphide of sodium solution is introduced into the bed at about its center, or in such other position that it has to flow through or over sufficient ferrate of soda to convert the soda into caustic soda before it reaches the walls of the tank. When the filter bed is exhausted, the double sulphuret of iron and sodium may be treated for the production of either sulphate or sulphite or hyposulphite of soda; but this treatment forms no part of the present process, as it will constitute the subject of a separate application for a patent.

In the foregoing description I have referred to the manufacture of caustic soda, and my invention is equally applicable for the manufacture of caustic potash, carbonate of potash being used instead of carbonate of soda in the preparation of the ferrate.

A NEW RETORT STAND.

This is a device of C. G. Moor, of London. The top and bottom rings are shown *in situ*



ready for use, the middle one showing the simple movement necessary to release the ring, when it may be readily shifted to the required height. The small figure A shows the action of the clasp, and it is evident that one great advantage over the old system is that the heavier the weight to be sustained, the greater becomes the grip upon the upright.

THE SEPARATION OF ROSIN FROM FATTY ACIDS.

By E. Twitchell.

The ethyl ethers of fatty acids, as is well known, are most readily formed by acting on an alcoholic solution of the latter with hydrochloric acid gas, the HCl merely serving to remove the water formed by the combination. This reaction I have found to be practically complete where the alcohol employed is absolute, and the HCl gas is passed to saturation. No other precautions are necessary.

On attempting to etherify resin acids (common rosin) in the same way, I found that no combination takes place between the alcohol and acid, and that, when the solution is kept cool, the resin acid is entirely unacted on, and can again be separated by diluting with water and boiling to collect the precipitate.

This important difference suggested a method for separating rosin from fatty acids which, on being practically applied, gave me separations such as I think are impossible by any of the methods now in use.

The analysis may be either gravimetric or volumetric, and depends on the fact that, by the means indicated, all the fatty acids are combined to form ethers which are neutral in alcoholic solution and unacted upon by alkalies in the cold, while the rosin is left as it was, reacts acid in alcoholic solution with phenolphthaleine and combines easily with caustic potash to form a soluble soap. It is therefore simply necessary to effect the combination of the fatty acids with alcohol, when the resin acids may be titrated with standard NaOH solution, using phenolphthaleine as indicator, or they may be combined with KOH, and the rosin soap thus formed separated from the unsaponified fatty ethers by extracting with naphtha in a separatory funnel.

The gravimetric method is carried out as follows: 2 or 3 grammes of the mixture of fatty acid and rosin are dissolved in ten times their volume of absolute alcohol in a flask, and dry HCl gas passed through in a moderate stream. The flask is set in a vessel with water to keep it cool. The HCl is rapidly absorbed, and, after about 45 minutes, the ethers separate, floating on the solution, and no more HCl is absorbed. The flask is removed and allowed to stand a half hour longer to insure a complete combination of the alcohol and fatty acid. It is then diluted with about five times its volume of water and boiled until the acid solution is clear, the ethers, with rosin in solution, floating on the top. To this is added some naphtha and the whole transferred to a separatory funnel, the flask being washed out with naphtha. The acid solution is then run off and the naphtha solution (which ought to measure about 50 c.c.) washed once with water and then treated in the funnel with a solution of 0·5 gramme KOH and 5 c.c. alcohol in 50 c.c. water and agitated. The rosin is immediately saponified and the two layers separate completely. The solution of rosin soap can then be run off, treated with acid, the rosin collected in any manner desired, dried and weighed. A second washing of the soap with naphtha is hardly necessary, as very little remains after the first extraction. The naphtha used is 74° gasoline, and for this purpose is much to be preferred to ether.

The first stages of the volumetric method are similar to those of the gravimetric, with the exception that the contents of the flask are washed into the separatory funnel with ether instead of naphtha, and the ether solution in the funnel is then thoroughly washed with water, until the wash water is no longer acid; 50 c.c. alcohol, previously neutralized, are then added and the solution titrated with standard NaOH solution. If the combining equivalent of rosin is known, its percentage may be calculated, or some of the original mixture may be also titrated, when the difference in NaOH required will correspond to the fatty acids converted into ether.

I have tested this method by a number of experiments, some of which I will here describe. As a first step it was necessary to determine the effect of HCl gas on alcoholic solutions of fatty and of resin acids separately.

(1.) Five grammes of distilled fatty acids were dissolved in 50 c.c. absolute alcohol, treated with HCl gas in the manner described, then treated with water, boiled, washed in a separatory funnel and dried. They yielded 5·451 grammes of ethyl ethers. These ethers were dissolved in neutralized alcohol and titrated with a normal solution of NaOH. They required for neutralization 0·14 c.c. of the solution. This would represent 0·97 per cent. of resin acid, taking 346 as the combining equivalent of rosin, *i. e.*, the weight of rosin neutralized by 1 c.c. normal alkali = 0·346 gramme.

(2.) Five grammes fatty acids from a low grade tallow were treated in the same way, and required 0·06 c.c. for neutralization = 0·14 per cent. rosin.

These figures, although not indicating a perfect combination, are still very small, and I think can be explained, especially in the first case, by the supposition that there were actually some resin acids present, natural constituents of the crude fats.

On attempting to use alcohol of 90 per cent. instead of the absolute, I could only succeed in etherifying 93 per cent. of the fatty acids.

(3.) Five grammes of an average sample of rosin were treated in exactly the same manner as in working with the fatty acids. After diluting with water and boiling, the rosin was collected by dissolving in a little ether and found to weigh 4·9382 grammes. This was dissolved in alcohol and required 14·27 c.c. of the NaOH solution to neutralize it. Five grammes of the original rosin were titrated and required 14·45 c.c. There had been a slight loss in drying, but no change in the combining weight.

It was found that if the alcoholic solution became heated by the HCl gas, or if the solution was boiled without first diluting with water, the rosin suffered some change and required less NaOH to neutralize it.

Analyses were made of a number of mixtures. In using the volumetric method the mean combining weight of fatty acids was taken at 275, and of resin 346.

A mixture consisting of 20 per cent. rosin, 80 per cent. f. a., gave, by the volumetric method, 20·36 per cent., 21·40 per cent., and 19·91 per cent. rosin. The same by the gravimetric method: 18·93 per cent. rosin.

A sample of soap said to be made of 100 parts fat to 40 of rosin, and therefore containing 28·67 per cent. rosin, assayed by the volumetric method 73·7 per cent. fatty acid, and by the gravimetric method, 25·7 per cent. rosin.

Unsaponifiable matter in the fat does not affect the process, but can be determined by the volumetric method in one operation, as follows: Two grammes of the original fatty mixture are titrated with normal NaOH solution and saturate a c.c. Two grammes are treated with HCl gas, etc., then titrated and saturate b c.c. Then

$b \times 0{\cdot}346$ = weight of rosin.
$a - b \times 0{\cdot}275$ = weight of f. a.

The remainder is unsaponifiable matter.

A mixture of rosin, fatty acid and paraffine was prepared and analyzed in this manner, with the following results:

	Calculated.	Found.
Rosin.....	21·3	22·6
Fatty acid.....	43·6	42·7
Paraffine.....	35·1	34·7

I have since analyzed a number of samples of soaps and always obtained the rosin distinctly brittle and therefore practically free from fat. This I found to be the case even when the percentage of rosin was so low as 4 or 5 per cent.

In my experiments the caustic soda solution was normal, but a more dilute solution might be used with advantage, as a smaller sample could be taken and the operation considerably hastened.

The figures given have been those actually obtained, without correction for error, such as unsaponifiable matter in the original rosin, which would affect the gravimetric determination. The volumetric method I should prefer in all cases except where an examination of the rosin was desired.—*Journal Analytical and Applied Chemistry.*

[Continued from SUPPLEMENT, No. 822, page 13135.]

THE USE OF COMPRESSED AIR IN CONJUNCTION WITH MEDICINAL SOLUTIONS IN THE TREATMENT OF NERVOUS AND MENTAL AFFECTIONS.

BEING A NEW SYSTEM OF CEREBRO-SPINAL THERAPEUTICS.

By J. LEONARD CORNING, A.M., M.D., New York, Consultant in Nervous Diseases to St. Francis Hospital, St. Mary's Hospital, the Hackensack Hospital, etc.

I THINK enough has now been said to exhibit in a striking manner the advantages of a therapeutic kind which would inevitably attend the embodiment of these fundamental facts in one comprehensive system. Such a combination I have succeeded in bringing about in the following way:

THE AUTHOR'S SYSTEM OF USING COMPRESSED AIR IN CONJUNCTION WITH MEDICINAL SOLUTIONS IN THE TREATMENT OF CEREBRO-SPINAL AFFECTIONS.—In the first place, I have had constructed a large metal chamber, capable of hermetical closure, and able to withstand a pressure equal to that of a locomotive boiler (Fig. 1). This chamber is cylindrical; it is six

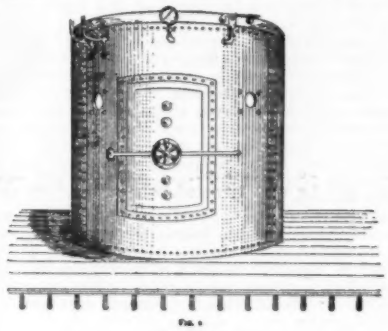


FIG. 1.

feet in diameter, six and one-half feet high, and its walls are composed of soft steel. The ends of the cylinder, which compose the top and bottom of the chamber, are five-eighths of an inch in thickness, while the cylindrical walls are somewhat less heavily constructed. The seams are not secured by rivets, but by bolts, so that the chamber was brought into my house in sections and erected in one of the consulting rooms without noise or other disturbance.

Access to this chamber is afforded by a massive door, swung from the center upon ponderous hinges, which peculiar arrangement admits of a very exact coaptation of the door to its frame. The edges of the latter are, of course, armed with a thick roll of India rubber. To further insure a hermetical closure an adjustable cross lever has been provided, so that a screw acting by the aid of a hinge from the center of the door upon this lever or cross bar enables one to draw the door—which opens inwardly—firmly against its frame.

The ingress and egress of the air, which is derived from a pump actuated by an electric motor of one horse power, are regulated by adjustable valves. By this arrangement it is possible to accurately regulate the amount of air pressure deemed applicable in a given case. In addition to these appliances a safety valve and pressure indicator have also been provided. The amount of pressure commonly employed is, however, vastly below the maximum point of endurance of the chamber, which, on account of its unusually solid construction, is capable of withstanding enormous strains. How great is this strength may be gleaned from the fact that, in its completed condition, it weighs over two tons.

I feel that great credit is due to the Cockburn Barrow and Machine Co., of Jersey City, for the conscientious manner in which they have performed this portion of the work. As is well known to the engineering fraternity, this firm has had an extensive experience in the use of compressed air in caisson and tunnel work, notably in the case of the Hudson River tunnel and the foundation work of the Hatteras lighthouse. It gives me pleasure to acknowledge my special indebtedness to Mr. William C. Barr and Mr. D. B. S. Cockburn, both of whom have been assiduous in their endeavors to render the mechanical details all they should be.

I cannot leave this portion of the subject without indicating briefly the principal features of the mechanism employed in condensing the atmosphere within the chamber. For this purpose I have had placed in the cellar of my house a one horse power electric motor, actuated by the current derived from the street conduits of the Edison Electric Illuminating Co. To the motor is joined, by appropriate belts and countershafting, an air pump (Fig. 2) of superior construction, and with a capacity of more than 140 strokes to the minute, the length of each stroke being six inches, and the diameter of the cylinder of the pump being also six inches.

By the aid of a system of wires, switches, and a resistance box one is able to start this mechanism from the floor above, in the immediate vicinity of the air chamber, without the slightest danger of causing a derangement of the belts and pulleys employed in joining the pump and motor together.

A strong tube of iron conducts the air from the pump through an aperture in the floor to the metal chamber; while a similar tube conducts the redundant air from

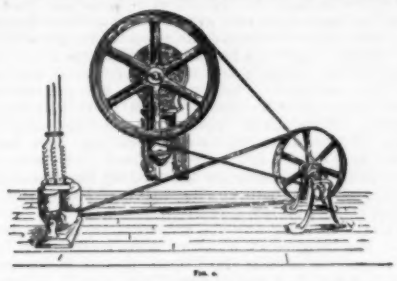


FIG. 2.

the automatic exhaust valve previously described. It is possible in this way to obtain pressures of from fifteen to thirty pounds in a few minutes.

It gives me pleasure to express my indebtedness to Mr. Hadley, of the Edison Electric Illuminating Co., who has superintended this elaborate installation with much diligence and skill.

Let me now describe, in as few words as possible, the manner in which I am accustomed to employ this apparatus in conjunction with medicinal solutions, for the purpose of increasing their pharmaco-dynamic effects, more especially as related to the cerebro-spinal functions.

As stated at the beginning of the argument, I esteem it of advantage, before introducing the remedy into the system, to sequestrate a certain amount of blood in one or more of the extremities. This may be done by passing a ligature around the limb so as to arrest the circulation in both artery and vein; or the ligature may be drawn only sufficiently tight to check the circulation in the cutaneous veins alone. While in the latter case the ligature is much better borne than in the former, so that it may be worn for protracted periods without inconvenience, it possesses the inconvenience that it causes an abnormal accumulation of blood in the extremity, with consequent inordinate exsanguination of the trunk and hence of the spinal cord and brain.

To avoid this depleting influence, however, it is only necessary to have the patient apply a moderately tight bandage in the form of an elastic stocking or sleeve (when the ligatures are applied to the arms) before adjusting the ligature (Fig. 3). In this way stasis

FIG. 3.

of the blood circulating in the veins may be obtained without depleting to any considerable extent the brain or cord, and without special inconvenience to the patient, provided that the elastic stocking or bandage has been applied in such a way as not to compress the veins, but merely to limit their expansion. This point I hope to have made sufficiently intelligible. The ligatures having been applied and the medicinal solution administered, either by the mouth, rectum, or hypodermically, the patient enters the pneumatic chamber, the air pump is set in motion, and by degrees the condensation of the atmosphere progresses until the desired pressure is obtained. When this point is reached the redundant air passes off through the blow-off valve, which, as previously mentioned, is automatic in its action and readily adjustable to any desired pressure.

I have rarely deemed it necessary to employ greater pressure than thirty pounds to the square inch (two atmospheres), and I often employ lower ones, especially when the delicate state of the patient's health seems to demand such a course. How long should the patient remain the condensed atmosphere? This question cannot be answered dogmatically; as a rule, however, an hour will be sufficient to insure an active therapeutic effect. Exceptionally, however, I have allowed the patient to remain in the air chamber for two hours or more.

And now let me add a few injunctions respecting the precautions to be observed in connection with the removal of the patient from the air-chamber into the normal atmosphere. In the first place, it is of the utmost importance that this transition from an atmosphere of high to one of relatively low tension should be gradually accomplished. To this end the air should be allowed to escape very gradually, so that from fifteen to twenty minutes are consumed in the operation of reducing the pressure in the chamber to that of the external atmosphere.

While this reduction of pressure is in progress, the tourniquet or strap employed in compressing the vessels is removed by the patient, but the elastic stocking or compress is allowed to remain. At the same time the subject swallows fifty or sixty drops of the aromatic spirits of ammonia to which caffeine, the sulphate of sparteine or some other heart-tonic may be added, at the discretion of the physician. This cardiac stimulant stands properly prepared upon a table in the air-chamber, and the patient is instructed beforehand when and how to take it. The combined effect of the elastic compress and the cardiac tonic is to increase the vaso-motor pressure in the cerebro-spinal system of vessels at the very moment when the compressed air is ceasing to perform that function. As a result of these precautions, I have yet to meet with a single untoward effect from this system of treatment.

Finally, the ventilation in the air-chamber should be carefully looked to, so as to avoid the inordinate accumulation of carbonic acid gas in the chamber and hence in the system; for when the system, and more especially the cerebro-spinal system, is overloaded with carbonic acid, grave disturbances of function may be induced, which manifest themselves after the subject leaves the compressed atmosphere. It is ignorance or disregard of this fact in connection with submarine work which has, I believe, given rise to many cases of severe caisson disease.

In the elaborate and roomy apparatus which I employ there is fortunately no danger of this or any other kind of accident, since the circulation of air is continuous and the pressure capable of exact and automatic regulation.

The next question which naturally suggests itself is, What are the remedies most suitable to be administered under pressure where a direct action upon the nervous system, and especially the cerebro-spinal system, is sought after? This question has already been briefly referred to at the beginning of this paper; but I should like to answer it somewhat more explicitly. In the first place, all chemicals which possess an affinity for nervous matter, as revealed by their ability to modify the functions of the central and peripheral nervous system, more especially the former, may be given with advantage while the subject remains in a condensed atmosphere. When I say that such substances may be given with advantage in this way, I mean that the intensity and permanency of their effects may be thus enhanced; or, in other words, they may be given with equal if not greater effect in much smaller doses, and the benefit derived lasts much longer.

A moment's reflection will suffice to convince any thoughtful physician of the significance and magnitude of these things from a practical point of view. It is, indeed, at once apparent that the discovery is capable of a wide application in the treatment of nervous derangements, especially those involving the brain or cord, or both. I have said that the remedies may be given hypodermically, by the mouth, or per rectum. I may add, however, that their exhibition by the mouth dissolved in some diffusible stimulant of an alcoholic nature is to be commended.

ILLUSTRATIVE CASES.—A brief synopsis of a few of the cases in which I have resorted to this system of treatment will best serve to give an idea of its effectiveness and wide applicability.

CASE I. *Pain Due to Morbid Irritability of the Cord. Spinal Irritation.*—Miss C——, aged forty-five. Had been treated by a number of physicians for obstinate dorsal and intercostal pain. The cautery, galvanism, and all the usual drugs, including strychnine, had been tried without avail. She was brought to my consulting room by one of my former patients, whom I had been fortunate enough to cure of obstinate headaches.

On physical examination, I found the spine tender on pressure in the cervical, dorsal, and lumbar regions; while such paræsthesiæ as tingling, numbness, and "burning" pains were promptly evoked when she attempted to walk or bend the trunk forward or laterally.

These symptoms had manifested themselves more or less constantly for the past three years; but there was no evidence of any organic alteration involving the nervous system. The pulse was somewhat sluggish, but the heart and lungs and the kidneys were healthy.

While the interview was still in progress she complained of feeling a great deal of pain, and wishing, if possible, to afford her some relief, I gave her twenty grains of antipyrin in a teaspoonful of the aromatic spirits of ammonia, well diluted with water. Although she was somewhat anæmic, there was no unpleasant symptom; but, unfortunately, neither was there the slightest relief, the pain persisting as energetically as before.

On the following morning she was again brought to my office in a carriage. Learning that she still suffered from the painful paroxysm of the day before, I gave her ten grains of antipyrin in a little alcohol, applied two ligatures above the knees, and then installed her upon a comfortable couch within the air chamber. During the first fifteen minutes the pressure reached eight or ten pounds to the square inch. Subsequently it was increased to twenty-five pounds, which point it was not allowed to pass, the blow-off valve being adjusted to that purpose. After remaining in the condensed atmosphere for three-quarters of an hour, the pressure was gradually reduced; and fifteen minutes later, the equilibrium between the air in the chamber and the external atmosphere being established, she rose from the couch and passed through the open door without assistance. She then stated to me in the most positive manner that not only was she now quite free from all discomfort, but that she had been quite relieved of pain after the first fifteen or twenty minutes of her sojourn in the condensed atmosphere.

There being no considerable return of pain the following day, treatment was continued as before, except that one-twentieth grain of the sulphate of strychnine was given hypodermically instead of the antipyrin before entering the condensed atmosphere. She was also placed upon the albuminate of iron and quinine, both of which she took for some time after the principal meal.

At the end of three weeks, there being no return of pain, she was allowed to discontinue treatment. Quite a long time has elapsed since then, but she writes me that she is quite well, and has gained considerably in weight.

CASE II. *A Case of Nervous Headache Promptly Relieved.*—This case is cited merely to show how

promptly a distressing phase of headache may be relieved by this plan of treatment, with a minimum of drugging.

Mrs. D. E——, a married lady of forty years of age, has suffered from severe attacks of headache of a "nervous" type for many years. As a rule, the paroxysm begins with more or less visual disturbance, the sight becoming clouded; and all attempts to use the eyes are followed by marked feelings of discomfort in the eyes and head. Nevertheless, there are no tangible ocular defects; the pain is not located in the eyeballs, but is ambulatory, predominating at times in the occipital region, at others in the forehead. The circulatory disturbances are inconsiderable, and do not merit special attention, either from an etiological or therapeutic point of view.

Although all the usual remedies have been tried, she has, until within the past six months, derived the greatest benefit from the use of the bromides. For some time, however, these have failed to abort the attacks of pain, so that she now refuses to further continue their use.

By dint of some persuasion, I finally induced her to take something less than her usual dose of the bromide of potassium, the constricting ligatures being first placed above the knee and elbow, and the elastic stockings being just tight enough to prevent inordinate distention of the vessels. In this way a very complete stasis of the circulation in the superficial veins of all four extremities was obtained; so that the amount of blood sequestrated, and hence uncontaminated by the drug, must have been considerable. On the other hand, the elastic stockings served to prevent any considerable exsanguination of the cerebro-spinal axis or the trunk as a whole, as was shown by the carotid pulse remaining unaltered.

Twenty minutes after taking the remedy, the patient declared that she was no better. She was then placed in the air-chamber, and the pressure increased to fifteen pounds to the square inch, at which point it was maintained for nearly half an hour. The pressure was then gradually reduced, as she intimated that the pain had entirely left her.

Case III. *A Case Showing that the Effects of Alcohol may be Greatly Enhanced by Exposing the Subject in a Condensed Atmosphere.*—R. E. A——, a young unmarried man, has been addicted to the habitual abuse of alcohol for many years. He states that at the present time he is obliged to take double the quantity which he formerly drank in order to obtain the slightest stimulating effect. I had him indicate on a tumbler his usual dose; and, as there exhibited, it could not have been less than two ounces, his tipple being whisky or brandy. Wishing to ascertain whether in so old an habitue the compressed air might be invoked as an aid to decreasing the amount of alcohol taken at one time, I gave him half his accustomed dose of whisky, and had him enter the air-chamber (without ligatures or elastic stockings). The pressure was then gradually increased to eighteen pounds to the square inch, and at this point it was maintained for twenty minutes, the air being renewed from time to time to insure a plentiful supply of oxygen. It was then gradually decreased till the pressure within the chamber equaled that of the external atmosphere. The door was now opened, the patient having been exposed to the influence of the condensed atmosphere for forty-five minutes, and to a maximum pressure of eighteen pounds for twenty minutes. He then stated that he was certain that the degree of exhilaration experienced was quite equal, if not superior, in degree to that usually derived from twice or even thrice the quantity of alcohol.

The capital significance of such an observation as the foregoing will, I am sure, impress itself upon every thoughtful practitioner.

Case IV. *A Case Showing Beneficial Influence of this System of Treatment in Simple Melancholia (without Delusions).*—A. S. E——, a young girl, aged eighteen, has suffered for the past few months from hysterical attacks, followed by periods of marked depression. She has neither hallucinations nor delusions, but she is irritable and obstinate, and at times difficult to control. Of late she has lost considerable flesh, her bowels are constipated, and, in fact, her whole physical condition is far from satisfactory.

Recognizing the paramount necessity of improving the general bodily state, I have had her drink warm milk—often as much as ten or twelve tumblers a day; I have given her, in addition, both cathartics and diuretics; and I have sought to have her take more air and exercise, at the same time endeavoring to promote sleep by the conservative exhibition of soporifics.

These things have already begun to do good; but, while she is more tractable and less inclined to cause worry to those about her, her attacks of depression, though perhaps not as frequent, are quite as severe as formerly. While suffering from one of these attacks of depression she was recently brought to my office by her mother; and, at my suggestion, she was placed in the air chamber, a small dose of the extract of absinthe and brandy having previously been given her.

In a short time the pressure was shown by the indicator to be fifteen pounds, and at this point it was maintained for twenty minutes or more. After a lapse of this period a marked change took place in the patient's appearance, as could readily be ascertained by looking through one of the large glass port-holes. Her face, which had previously worn a dejected indifferent appearance, now displayed a contented and even happy expression, and she occupied herself with reading the newspaper—something that she had not done before for weeks.

On leaving the air chamber this air of contentment remained and, according to her mother's statement, she showed no further evidence of depression for the next three days.

Though I had employed the above remedies, and various others as well (without the compressed air), on former occasions and in larger doses, it had never been my good fortune to obtain any appreciable immediate good from them. I feel, therefore, entirely convinced—more especially as I have since been able to produce the same class of effects on several occasions, both in this and other patients—that the enhanced potency of the drugs was entirely due to the concomitant influence of the compressed air.

Case V. *A Case Showing the Enhancement of the Soporific Powers of Hypnotics, and more Especially of Chloralamid, by the Administration of the Same while the Subject Remains in a Highly Condensed Atmosphere.*—E. N——, a neurasthenic woman who has suffered from acute insomnia for several weeks, and who is inappreciably influenced by the usual hypnotics or their combinations, even when given in large doses.

Among other soporifics I have given her chloralamid in doses of forty-five grains, but with quite insignificant success; for in spite of the remedy she declares that she never sleeps more than one hour or two out of the twenty-four. At my suggestion she consented to try the effects of the compressed air treatment.

Accordingly I gave her a dose of thirty grains of chloralamid—fifteen grains less than she had previously taken at night; and, fifteen or twenty minutes after its administration, the elastic straps having been previously adjusted to the lower extremities above the knees, she entered the air chamber. The pressure was then raised to fifteen pounds to the square inch, as shown by the gauge; and at this point it was maintained for upward of half an hour, the air being renewed from time to time, but without altering the pressure. While thus exposed to the concomitant influence of the drug and condensed air, she became drowsy, and finally fell asleep. From this state of unconsciousness she was only aroused by the noise of the escaping air as I opened the valve of the outlet tube in order to empty the chamber.

On the following day she stated that, at the conclusion of the treatment, she had gone home, and laying down upon the lounge, had immediately fallen asleep, only awaking after the lapse of five or six hours. In other words, she had slept the entire afternoon—something that she was quite unable to accomplish, even previous to the attack of insomnia.

This case is instructive, as exhibiting the continued good effects of this plan of treatment; by which I mean that the soporific tendency persists even after removal of the patient from the condensed atmosphere. I will merely add that this case went on to complete recovery, natural sleep supervening regularly without artificial assistance of any kind after treatment had been continued for four weeks.

Case VI. *A Case Showing that the Soporific Powers of Sulphonal can be neither Enhanced, Accelerated, nor Prolonged by the Concomitant Exposure of the Patient to the Influence of Compressed Air.*—F. I. T——, a Polish Hebrew in middle life, consulted me for insomnia, which he states came on as a sequence of the "grippe." Having adjusted the ligatures about his limbs, I gave him fifteen grains of sulphonal, and half an hour later placed him in the chamber. The air pressure was then raised to fifteen pounds to the square inch, at which point it was maintained for over an hour. After leaving the air chamber he stated that at no time had he felt the slightest drowsiness; and moreover, on returning the following day, he declared further that the postponed soporific effects so frequently due to the drug were entirely absent.

Subsequently, I gave him small doses of chloralamid, which were exhibited under precisely similar degree of pressure (fifteen pounds to the square inch) and with the result that sleep could be induced at pleasure either by day or night. Eventually he recovered completely.

I have cited this case merely to show that sulphonal is not a remedy which is well adapted to be used in conjunction with compressed air.

Case VII. *A Case Showing that the Potency of Diuretics (or at least of some Diuretics) is Enhanced by their Exhibition while the Patient Remains in a Condensed Atmosphere.*—W. E——, a man of middle age, a sufferer from chronic nephritis. I was consulted with regard to various nervous symptoms, notably irritability and insomnia, from which he had been suffering for several months past, but notably so during the past six weeks.

When I saw him, he had been taking copaiba for some time, and his stomach had become weak and inefficient. In the course of various suggestions pertaining to the management of the neurotic phase of the case, I availed myself of the opportunity thus afforded to recommend that colchicin be substituted for the copaiba capsules.

This was accordingly done, the remedy being exhibited in $\frac{1}{75}$ grain doses. For some reason the quantity of urine excreted was not materially enhanced; and, being informed of this fact, I suggested, merely as a matter of scientific interest, that the remedy be given in conjunction with the compressed air.

He readily consented to this, and I gave him the usual dose of the remedy, and shortly afterward had him enter the air chamber, where he remained for over an hour at a pressure of eighteen pounds to the square inch. During this time the air was renewed, but without altering the pressure. In the afternoon the same operation was repeated, the patient remaining even a little longer in the air chamber.

The amount of water excreted during the progress of these observations was collected and measured, with the result that it was found to exceed in quantity that previously passed during the same interval by about one-third.

This observation, though, strictly speaking, without the limits of the subject under consideration, possesses, nevertheless, an undoubted collateral interest, inasmuch as it demonstrates that the vaso-motor pressure in the structures contained within the abdominal cavity is enhanced—though not to the same degree as in the cerebro-spinal cavity—by exposing the subject to the influence of a highly condensed atmosphere.

Corollary to Argument.—Final Summary.—The procedure which we have now elucidated with sufficient minuteness consists, then, in the following elements: 1. Sequestration of the peripheral circulation, especially in the extremities, either by the application of ligatures which compress both arteries and veins, or the arteries alone, or the veins alone. As previously stated, I prefer the latter expedient provided it be combined with the simultaneous application of an elastic compress (stocking) below the ligature, so as to restrain the expansion of the veins, thus preventing the undue accumulation of blood and consequent exsanguination of the trunk. 2. The introduction of a chemical having an affinity for nervous matter, and especially for that composing the cerebro-spinal axis. 3. The immersion of the subject in air condensed much above the pressure of the normal atmosphere.

We have already considered a variety of effects produced upon the system, and particularly the cerebro-spinal system, by a plan of treatment embodying these three elements. Something has also been said regarding the causation of these phenomena; but the subject is capable, I think, of somewhat further elucidation. I shall, therefore, bestow a few parting thoughts in giving a more comprehensive answer to the question: Why is it that cerebro-spinal medicaments, when given in this way, are enhanced and, to a certain degree, prolonged in their effects; or, to state the matter still more concretely, how does it happen that we may give a certain amount of a remedy in the usual way, either by the mouth, rectum, or hypodermically, without visible effect upon the central nervous system, and yet may obtain characteristic effects from that remedy when given in the same dose as before—or even in a smaller one—if we call in the aid of the ligature and compressed air in the manner previously set forth? I shall endeavor to answer this question as succinctly as possible.

In the first place, by applying the ligatures in the manner previously set forth we cause a more or less extensive stasis or sequestration of the peripheral circulation, thus reducing the amount of blood to be impregnated with the medicinal substance. In other words, we have only the blood in the trunk to medicate, while that contained in the limbs—provided we apply the ligature to both arms and legs—remains uncontaminated. Consequently, the dose of medicinal substance, being distributed only throughout the blood-mass contained in the trunk, arrives in a much more concentrated condition in contact with the cerebro-spinal axis than would have been the case had the subdivison extended to the blood contained in the limbs.

To all physiological intents and purposes the size of the individual has been curtailed; and we all know that the smaller animals—other things being equal—are much more susceptible to the influence of medicinal substances, and this is especially true of stimulants and sedatives, than the larger ones. How does the compressed air assist in still further enhancing the physiological effect of the remedy?

To comprehend how this is accomplished it must be borne in mind that the quantity of blood circulating in the trunk is not reduced in volume—or but slightly so—by the application of the ligatures, but is merely shut off, sequestrated as it were, from that contained in the extremities. Consequently, when the condensed air presses upon the blood circulating at the surface of the trunk, it (the blood) is forced in the direction of least resistance, *i. e.*, the cerebro-spinal cavity. Hence the vaso-motor tension will be greatest at this point, and as a result of this, the transudation of the medicated blood into the tissue of the brain and cord will be greatly enhanced. This, so far as my physiological apprehension serves me aright, is the true explanation of why the effects of a large class of cerebro-spinal remedies are so strikingly enhanced by their exhibition while the subject remains in a condensed atmosphere, with ligatures adjusted to the extremities in the manner previously described. Moreover, in my opinion, the perpetuation of the beneficial effects is due in no small degree to the nutritive changes which are more or less directly traceable to this increase in vascular tension.

From the facts and considerations already brought forward I think it will be admitted that this system of using compressed air in conjunction with medicinal solutions is capable of extensive application in the treatment of nervous and mental affections, more especially those of functional origin of a rebellious and unyielding type.

For an extensive list of the literature of compressed air the reader is referred to my paper on the "Caisson Disease."*

LOTIONS FOR BALDNESS.

Dr. Tom Robinson, who has made diseases of the hair a special study, recommends for baldness occurring in young ladies and premature baldness in men the following washes. The alkaline lotion is to be used for a week, and afterward the acid one. The rubbing must be done with a piece of flannel or sponge:

Alkaline.

Borax	1 drm.
Glycerine	2 "
Tincture of cantharides	6 "
Solution of ammonia	1 oz.
Essential oil of bay	4 drops.
Water	to 6 oz.

M.

Acid.

Aromatic vinegar	2 drm.
Glycerine	2 "
Rectified spirits	1 oz.
Blistering liquid, B.P.	1 drm.
Orange flower water	2 oz.
Rose water	to 6 "

M.

ELIXIR OF PEPSIN AND BISMUTH.

(*Liquor Pepsin et Bismuthi.*)

Pure pepsin	128 grn.
Citric acid	120 "
Bismuth ammonio-citrate	128 "
Stronger white wine	8 fl. oz.
Spirit of orange	2 fl. drm.
Sugar	4 troy oz.
Water of ammonia, Water,	of each a sufficient quantity.

Dissolve the citric acid in 4 fl. oz. of water, and rub up the pepsin with this solution; add the wine, and gently warm at a temperature of not over 100 deg. F. until the pepsin is dissolved. Dissolve the ammonio-citrate of bismuth in 1 fl. oz. of water, with the aid of a few drops of ammonia water, and add this solution to the pepsin solution, and then gradually add ammonia water until the solution becomes perfectly clear and neutral, or very slightly alkaline. Now add the sugar, spirit of orange, and sufficient water to make 16 oz. Filter if necessary.

This preparation contains 1 grn. each of saccharated pepsin and ammonio-citrate of bismuth to the fluid drachm.—*G. M. Beringer, in Amer. Jour. Pharm.*

* Observations on the Caisson or Tunnel Disease, the *Medical Record* for May 10, 1890.

RICE, ITS HISTORY.

By Mr. H. B. PROCTOR.

"Thus God created man. God made food and drink, rice, fire, and water, cattle, elephants, and birds.—A Burmese account of the creation.

EXTRAORDINARY as has been the progress of the wheat trade of England during the last century, the wheaten loaf having supplanted those of rye and barley as the staple food of all classes of the people, it nevertheless will not bear comparison when contrasted with the same movement in rice, the importation of which has increased not less than one hundred fold during the same period.

The rice trade of England continued in extremely small compass, and was limited to the varieties produced in Carolina, Bengal, and Madras, until the year 1852, when the most fertile provinces of Burma were conquered and annexed to the British empire.

Of all the countries in the world, Burma is the best adapted for the cheap cultivation of rice; all that was wanted was a just and strong government, able to put down petty internal warfare, and willing to protect the cultivators from excessive taxation, violence, and oppression.

These blessings, which universally attend British rule, soon changed the condition of the people from extreme poverty to the greatest prosperity. As soon as the war was over, and the country became settled, the export trade in rice began, and since then it has steadily increased year by year, until in 1881 the exports to Europe amounted to no less than 736,650 tons, besides which 178,600 tons were exported coastwise and to other parts of the world.

This immense addition to the rice supply of the world has not checked the trade in the same article from the rest of India, as might have been anticipated, but it has grown larger too; last year, the exports to Europe amounted to 89,650 tons.

A cereal trade that is developing with such rapid strides cannot fail to be of interest to the milling world. As the subject has hitherto been somewhat overlooked and neglected by periodicals devoted to such subjects, we propose to give a short account of the history, cultivation, and manufacture of rice and its products, together with a few remarks upon its comparative food value.

The derivation of the word—arisi, Tamil; aruz, Arabic; oryza, Latin; riso, Italian; rice, English—points correctly to its Indian origin. It is a cultivated variety of an aquatic grass, bearing when in the ear a closer resemblance to barley than to any other of the English corn plants.

The seed vessel grows upon separate, fine, hair-like stalks like the oat, each of which springs gracefully upward from the main stem. The grain is inclosed in a rough yellow husk, which generally terminates with a thin spike or awn, though some varieties are awnless. The height varies from two to six feet, according to the variety. The grain must be removed from the husk, which adheres to it with great tenacity, either by being pounded in a stamper pot or more generally by passing it through a pair of mill stones, set a slight distance apart, which crack off the husk without crushing the grain. It has next a thin skin or pellicle, which must be removed by scouring or decorticating, to make clean rice, just as barley is scoured for making pearl barley. Rice in the husk is called "paddy" (Malay, padi); the husk which is removed is called rice shude; the meal which is obtained during the process is called rice meal.

There are far more cultivated varieties of rice differing more from each other than there are of wheat, or any other of the grain foods. The Karens, a hill race in British Burma, have names for forty varieties. Dr. Moore mentions 161 varieties growing in Ceylon, besides which there are those grown in China, Africa, Japan, and other parts of the world. The colors of the grain vary from coal black, dark red, pink, yellow, to ivory white; the shapes are various, and differ much from each other; some varieties are sweet, some others bitter; some oily, others dry; some hard and translucent, others soft and chalky. Botanists have classified the varieties into four divisions: early rice, common rice, clammy rice, and mountain rice.

Early rice is a marsh plant. It is sown between the end of March and beginning of May. It matures in four months. It is grown mostly in India, China and Japan. Carolina and Java rice belong to this division. The isolated attempts which have been made to grow Carolina rice in Burma have failed, because it ripens sooner than the main crop of the country, and the birds collect in such numbers as to clear off the bulk of the crop before it can be gathered in.

Common rice gives the greatest yield—about twenty-five fold. It is wholly a marsh plant. If the ground becomes dry before it arrives at maturity, it soon withers away. The Burmese crop belongs to this division. It is sown in June and reaped about six months after.

Mountain rice grows on the Himalayas. It does not require irrigation and will stand great cold, pushing its way through snow. It has been grown as an experiment in England.

Clammy rice has the advantage of growing on wet or dry lands. It ripens in five months. Varieties of the two first divisions are those most known in commerce.

There can be no doubt that the rice plant is of Indian origin. Wild rice, growing in the waste marshes, is still eaten as a luxury on the Madras coast. The grain is small, white, and sweet; it brings a high price, but the plant does not pay to grow, because it returns so small a yield compared with the cultivated varieties. Rice is the grain food most preferred by half the human race. In the Indian peninsula it is the principal food of 100,000,000 of the people; so strongly are they impressed with the superiority of rice as a food, that in Southern India a peasant will indicate his well-to-do or impoverished condition by telling you that he eats rice twice a day, or once only, or not at all. But the poorest people rarely taste it; they eat varieties of millet, raggy deri, or other cheaper foods.

Tradition teaches that rice is the most ancient food of India, and as such it is invested with almost a sacred character. It is used in many of the sacrifices and other religious ceremonies. One of the purificatory rites after birth is feeding the Hindoo infant with rice during six months. The Hindoo household must daily perform the five acts of worship, the fourth of which is scattering rice grains at his door, with the prayer: "*Om to all the Visvadevas, to the universal gods, men, beasts, birds, reptiles, etc.*" After death comes the most important rite of all, called "Araddha," which is offering the pinda or ball of rice accompanied with prayers and libations to the departed spirit. The participation in this rite is accepted as evidence of kinship, and gives a title to a share of the deceased's property.

The most ancient written account of the cultivation and trade in rice, as far as I have been able to ascertain, may be found in the Shoo-King or Chinese classics, translated in Medhurst's Ancient China, which describes the drainage and irrigation works constructed by the Emperor Yu, on the Yangtse river, about 2356 B. C., a few years before the date usually given to the Noachian deluge. It describes the mode of collecting revenue from the paddy lands, as follows: "To the distance of 500 le (140 miles) from the Royal City was the land of feudal tenure; for the first 100 le (28 miles), the revenue consists of the entire plant of the grain; for the second 100 le; they had to pay the grain and half the straw; for the third 100 le, they had to bring the grain in the ear, while all these rendered feudal service; for the fourth 100 le, they paid the grain in the husk; and for the fifth 100 le, they brought the rice cleaned."

A most ingenious mode of collecting the revenue where the cost of carriage is so great, and the roads so bad, as they are in China to the present day.

Coming nearer home, rice may certainly take its place among the cereals cultivated in ancient Egypt and Syria. Pliny, the naturalist, does not give it in his list of Egyptian plants, but Wilkinson considers there is abundant reason for supposing it was cultivated in the Delta. This is confirmed by illustrations taken from a tomb at Thebes, some 3000 B. C. Wilkinson supposes that it represents the pulverizing of certain substances in a mortar. If it be compared with the process of rice cleaning as carried on in China at the present day, there can be no doubt but that it represents the same process as it was practiced in ancient Egypt nearly 5,000 years ago. It is done by pounding the rice in wooden or stone pots, with a pointed pestle or beater. The pot is kept full of grain, so that the skin is removed by the continued trituration and friction of one grain against another, without pulverizing or breaking them. Another process is worked by the foot, which is the method preferred in Burma, Japan, and parts of China. The operation is referred to in Proverbs, xxvii., 22: "Though thou shouldst bray a fool in a mortar among wheat (grain?) with a pestle, yet will not his folly depart from him," or as the same idea is rendered in one of our own proverbs, "Folly is more than skin deep." There is no sense in the translation as given in the authorized version. The word translated "wheat" means, literally, "pounded grain," and, undoubtedly, refers to the decorticating process, which, according to Pliny and Herodotus, was applied to rice and barley but not to wheat.

Pliny's description of the rice plant seems to show, though he knew the grain, he had never seen it actually growing, the description is so wide from the mark. In his treatise on the food plants of India he says: "But the most favorite food of all these is rice, from which they prepare ptisan (pearled grain) similar to that prepared from barley in other parts of the world. The leaves of rice are fleshy, very like those of the leek, but broader; the stem is a cubit (18 inches) high, the blossom purple, and root globular, like a pearl in shape" (B. 18, cap. 13). He goes on to say that "Hippocrates, one of the famous writers of medical science, has devoted a whole volume to the praises of 'ptisan,' the mode of preparing which is universally known."

The cultivation of the plant in Europe was, according to Captain Baird Smith, introduced by the Moors into Spain in the eleventh century, and from thence into Italy a century later. Gibbon considers that it was cultivated in Spain before the Christian era, and that the rice was imported from Spain which was used for making the wedding cake in the simple confarreation ceremonies of the old Roman republic. Be this as it may, it is certain that it was not cultivated to any large extent in Italy until quite modern times.

Rice cultivation has always been heavily taxed, and in some of the States absolutely prohibited, owing to the malaria rising from the swampy lands. Since Italy became a kingdom and legislation on the subject has become more uniform and less capricious, the cultivation of this, the most profitable crop to the farmer, has so extended in the rice meadows of Lombardy and other similarly situated low-lying lands that the Italian rice crop of 1880 amounted to no less than 500,000 tons, and it is annually increasing in amount. The cultivation of rice in Georgia and Carolina, which have produced the finest seeds in the world, only commenced about the year 1790.

In a pamphlet published in London, in 1701, on "The Importance of British Plantations in America," it is mentioned as a recent circumstance that "a brigantine from the island of Madagascar happened to put into Charleston, having a little rice seed left, which the captain gave to a gentleman named Woodward. From part of this he had a very good crop, but he was ignorant for some years how to clean it. It was soon dispersed over the province, and by frequent experiments and observations they found out ways of producing and manufacturing it to so great perfection that it is thought to exceed any other in value." Mr. Dubois, the treasurer of the East India Company, sent a further supply of seed a few years afterward. By careful selection of the seed, and cultivation in trenches on a suitable soil, the Carolina seed has become so famous that it has been exported to Java, Italy, Madras, and other countries. The finest Indian varieties are grown from American seed.

Since the American war and the abolition of slavery, as the free negroes object to working in the swampy rice lands, associated as they are with fever and malaria, rice cultivation is becoming less each year, and the export trade of Carolina rice to Europe, in spite of all attempts to bolster it up with protective duties, has practically ceased. The American millers are losers rather than gainers by the duties imposed for protecting the trade, which is now two and one-half cents per pound, or over 100 per cent. *ad valorem* on imported cleaned rice, thus causing the American consumer to pay double for his rice. As the crop raised is smaller every year, he has not only no rice to export, but must import the balance of his supply from the English or other markets. Were the duty removed, the more expensive Carolina rice would again be largely exported to Europe, and be replaced by a still greater import of Burmese rice for the American home trade, to the benefit of cultivators, millers, shippers, and all concerned; a remarkable instance of injury done to a trade by the duties intended to protect it.

It is difficult to trace the time when rice was first imported into Great Britain. Shakespeare mentions it as a great luxury. The clown in Winter's Tale says: "Three pounds of sugar, five pounds of currants, rice; what will this sister of mine do with rice? But my father hath made her mistress of the feast, and she lays it on." The supply then came from Italy. It was superseded early in the eighteenth century by rice from our American colonies and India. We did not begin to mill rice for ourselves to any appreciable extent until the early part of the present century. McCulloch in his Commercial Dictionary, in 1832, tells us that "a few years ago England was principally supplied with clean rice direct from Carolina; latterly it has been much reduced. An improved mode of separating the husks, which throws out the grain clean and unbroken, has been lately practiced in this country. As the grain preserves its sweetness and flavor better during a long voyage then when shelled, it is now principally imported rough from Bengal and the United States. No doubt the heavy duty (15s. per cwt.) on American cleaned rice has powerfully contributed to this result." He says the consumption, which was lately only 2,000 to 2,500 tons annually, is rapidly increasing, partly owing to the late reduction of the duty on Indian rice from 5s. to 1s. per cwt. It has now, however, been very generally introduced among the middle and to a certain extent among the lower classes; there can be little doubt that its consumption will continue to increase according as the various qualities of this cheap and highly useful grain come to be known. It is likely, therefore, that it will in the future form an article of importance in the trade with India.

The experiences of the last half century show how these anticipations have been more than fulfilled. The rice imports have during that period increased a hundred fold; the increase still continues, and there is a fair reason to suppose that the commercial enterprise, industry and mechanical ingenuity of the English people will, for many years to come, in spite of Continental opposition, enable them to still farther develop and retain the foremost position in the rice trade of the whole world.—*La. Planter.*

SWEET PEAS.

REV. W. T. HUTCHINS, who has made a specialty of these plants, has written an instructive essay about them for the Tolland County, Conn., *Leader*, from which we extract the following by permission:

"There is some uncertainty as to how many so-called varieties really deserve the name; but they may be divided into three classes:

"The first class includes those with the form of the old-fashioned sweet pea. There are about thirty named varieties of these, and cultivation is putting new blood into them, so that they are now conspicuous for beauty of color and size. These principally take their variety name from the color or markings of the standard, that is, the single erect petal which rises back of the wings. To this class belong the new Blanche Ferry, which is a great improvement on the old Painted Lady, and has a brilliant rose-pink standard and white wings; Scarlet Invincible, a dazzling scarlet, both in standard and wings; Invincible Carmine and Cardinal, both but slight variations from the Scarlet; Vesuvius, blue and violet, shading into white and dotted with crimson spots; Duchess of Edinburgh, an orange-scarlet standard, margined with white; Primrose, with a suggestion of buff yellow; Orange Prince, the finest of this class; the Black and the White, two familiar sorts, but now cultivated to a remarkable size; Salmon or Flesh color; Crown Princess of Prussia, a delicate blush; Captain Clarke, of which the newer strain deserves to be called Columbia, because it is red, white, and blue; Scarlet Striped, now improved into Queen of the Isles, a magnificent flower; Adonis, a uniform pink; Boreatton, the finest of all the darker kinds, a deep velvety maroon, both standard and wings; Purple and Brown, and Blue and Purple, and both of these beautifully marked with stripes; Violet Queen and Princess Louise, shades of violet; the Queen, lighter shades of mauve and violet; Fairy Queen, white, delicately lined with crimson; Isa Eckford, a beautiful blush; Delight, suffused with crimson; Blushing Bride, an improvement on Blanche Ferry; Purple Prince, and many more.

"The second class is distinguished by flowers of a newer form, and in some of the larger ones the fullness of size produces a wavy look. Among these are Apple-blossom, a beautiful rose and white; Splendor, a deep rose color, half of the stems bearing four blossoms each; Indigo King; Grand Blue; Imperial Blue or Mauve Queen; Butterfly, shaded blue and white, and sometimes blue-edged; Princess Beatrice, a fine rose-pink; Senator, chocolate and white stripes; Princess of Wales, blue and white stripes; Countess of Radnor, very choice, a soft lavender, shading into mauve; Monarch, Miss Hunt, Mrs. Gladstone, Mrs. Sankey, Princess Victoria, Queen of England and Empress of India.

"The third class includes the new hybrids, some of which are promising, and others simply show their shifting nature. By the way, there seems no reason why the production of new varieties by hybridizing cannot be accomplished as well in this country as in England. The odd little blue pea, Lord Anson, deserves mention here. In a mixed row it has a decided value, though it is not properly a sweet pea, and has nothing but its bright azure color to commend it. The red and white perennial peas, bearing their showy blossoms in clusters, are also well worth growing.

"For cultivating sweet peas, there are six simple requisites, but they are inexorable. Of course, such general rules as rich ground, sunny exposure, and thorough weeding are understood. The special requirements are: (1) early planting; (2) deep planting; (3) extra fertilizing; (4) strong bushing; (5) watering; (6) free picking, which means keeping the pods off. Plant-

ing early means as soon as the ground can be worked. Sweet peas are very hardy, and, like the earliest garden peas, need to make their root growth in the cool, moist spring ground. Frosts need not be feared. Sometimes they are planted in the fall. Deep planting is very important to guard against the drought of midsummer. They should be planted five inches deep, but to cover them with five inches of cold, wet March soil almost insures failure. Hence they should be sown in a trench or furrow at the right depth, and covered but one inch at first. As they grow the earth is filled in, until when leveled they are at the right depth. They should be sown in a double row about ten inches apart, and the seeds dropped an inch and a half apart in the furrows.

"By extra fertilizing is meant the application of such stimulants as wood ashes, bone flour, and nitrate of soda. The garden should be well manured in the fall to give the soil a good body of vgetable matter; but to get a quick growth of thrifty vines and early flowering the above named plant foods are excellent. Scatter the wood ashes on in the winter: hoe in the bone flour just before bushing; and, in May, scatter along, just outside the rows, a handful of nitrate of soda for every four feet, stirring it in, but not allowing it to come into immediate contact with the vines. They will then grow a foot a week in June, and one can look for blossoms a month ahead of the man who believes in the 'good old way.' This kind of cultivation necessitates strong and tall bushing. Get the best birch tops, at least seven feet high, and, if two inches thick, all the better, and set them firmly in the ground with a crowbar. Bush between the double row, and train the vines to the bushes if they rebel. Where bushes cannot be obtained resort must be had to a trellis of poultry wire or a frame, with horizontal wires or strings, taking great care to secure strength and height. It is a calamity to have a thrifty row lop over or blow over in the height of the season.

"An ample supply of water is always needed, and in a dry season it must not be neglected. A rainy summer is friendly to sweet peas, and gives us about as good conditions as they have in the moist climate of England, where they flourish. Pick the blossoms every day; sacrifice the pods if you want flowers from June till October. You cannot have blossoms and save your own seed; if you did save it from a mixed row it is very sure to be unsatisfactory."

GREEK SCULPTURES.

A CORRESPONDENT of the *Manchester Guardian* writes: An interesting discovery is reported from Athens. In the works connected with the extension of the Athens-Piræus Railway a few months back there was found at a spot northeast of the Theseion a square block of Parian marble, which had formed the base of some dedication. On the front is an inscription recording as follows: "In the cavalry sham fight these commanders of squadrons (*Phylarchi*) won. Demainetos, son of Demeas; Demeas, son of Demainetos; Demosthenes, son of Demainetos. All of the deme Paianieus. Bryaxis made me." On each of the three remaining sides is sculptured in relief a tripod and a bearded horseman. Judging from the remains on the upper surface, this base seems to have supported a small Ionic column, on which probably stood the tripod of bronze or silver which commemorated the victory. This has of course perished, but in the reliefs on the base we are fully warranted in recognizing the work of Bryaxis's own hands. It was a regular practice among the great Greek sculptors to decorate their own bases, and moreover the excellence of the work fully justifies this attribution here. The discovery is the more important because nothing has hitherto come down to us which could be definitely connected with this celebrated artist. That his reputation as a sculptor was considerable we know from the general testimony of antiquity, and also from the fact that he was chosen with Skopas and Leochares to decorate the mausoleum at Halicarnassus. Bryaxis was an Athenian, but, judging from the record of his works, must have spent much of his life in Asia, as we hear of him at Rhodes, Knidos, Antioch and Patara in Lycia. In all probability, then, his work at Athens must have taken place before his work on the mausoleum, that is to say, shortly before 350 B. C., and this date would suit the characters of the inscription and the style of the sculpture. The three horsemen are evidently portraits of the Phylarchi whose names are recorded; one figure seems to be older than the others, and is probably intended to represent Demainetos, the father of Demeas and Demosthenes. The formation of these three names recalls a practice familiar to the Greeks of the best period, in which the family names usually ring the changes on one or two compounds of words. Here the names are all compounded with Demos. One is naturally reminded of the fact that the great Athenian orator was Demosthenes, son of Demosthenes, and belonged to the same deme Paianieus. If the sculpture of Bryaxis is correctly attributed to about 355 B. C., the orator must have been when this was executed exactly thirty years old, and may very likely have witnessed the cavalry maneuvers in which his relations were successful.

COAL.

"COAL" was the subject of Professor T. Rupert Jones' address to the Geological Section of the British Association. It consisted in the main of a description in detail of the coalfields of South Wales. The total output for 1880 was 21,165,580 tons, and in 1890 it was 29,415,025, an increase of 8,249,445. Incidentally it was also mentioned that the total output for the United Kingdom was 146,969,409 tons in 1880, and in 1890, 181,614,288 tons. Continuing, Professor Jones said that the formation and subsequent arrangement of coal and the coal measures had been so ordered that the blessings of civilization had been largely enjoyed wherever the fossil fuel at man's feet had been industriously worked by his hands, and carefully applied to the improvement of his social being. These labors of careful perseverance, and arts of skillful manipulation, had given special characters to those whose energies had been directed to coal mining and various manufacturing enterprises; and all conditions of society had been influenced thereby. So also the geologist, chemist, and botanist, seeking out the composition of the various coals, their local position and extent, their special natural history, the mode of passage from dead plants to first-rate fuel—in fact, aiming at a complete mastery over all the mazy events and complicated results of the coal formation—not only found a useful exercise of their cultivated intelligence and accumulated knowledge, benefiting all by the practical results, but widened the mental culture of others, and showed how the study of nature was an indispensable element in good education, and necessarily productive of lasting benefit to society at large. Light, heat, motion, fragrance, and color were all now obtainable from coal. What more could the sun himself do for us? It was as if the sunshine that cherished the luxuriant jungles of the past had been preserved in the coaly mass of the buried trees. Indeed, the light and heat of former days, expended in thus converting carbonic acid and water into coal, were here stored up for man. By converting coal into carbonic acid and water he could again evolve that heat and light, and use them in a thousand ways beneficial to his race—nay, essential to his very existence as a civilized being. Nevertheless, a great deal had yet to be learnt about the natural history of the coal measures, the order and extent of the special kinds of their animals and plants, the time occupied in formation, and the geographical and hydrographical conditions. At all events, we knew that all their strata had been arranged in order, had been buried under circumstances favorable to production of the various coaly fuels, and then turned up in orderly disorder, ready to the hand of man, and well adapted for his use in this passage stage of his civilization and development, helping him, when intelligent, active, careful, and persevering, to higher ends. For we could not doubt that all things here were arranged for his better being, his progress toward more and more useful arts, wider ranges of science, and fitter aptitudes of life, of which as yet we had but little conception. We were still the early settlers in a beautiful world, whose capabilities, imperfectly known as yet, waited until higher developments of man could understand them fully and apply the results to the general good.

In the Biological Section the President, Mr. Francis Darwin, of Cambridge, dealt with the subject of "Growth Curvature in Plants," and Professor Cunningham, of Cambridge, addressed the Economic Science and Statistics Section on "Nationalism and Cosmopolitanism in Economics."

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TABLE OF CONTENTS.

PAGE

I. ARCHÆOLOGY.—Greek Sculptures.—An interesting discovery reported from Athens, including an inscription with sculptures... 13158

II. BOTANY.—Rice—its History.—By Mr. H. B. PROCTOR.—How rice has been and is treated by the cultivator and miller..... 13157
Sweet Peas.—The division of sweet peas into appropriate classes..... 13157

III. BIOGRAPHY.—Hermann von Helmholtz.—By HUGO KRONECKER.—A very graphic review of the life-work of the great physicist by one of his students.—With portrait and bibliographical references.—1 illustration..... 13157

IV. CHEMISTRY.—A New Retort Stand.—A convenient laboratory adjunct.—1 illustration..... 13154
On Nickel Carbon Oxide and its Application in Arts and Manufactures.—By LUDWIG MOND.—A highly remarkable compound recently discovered described, with full particulars of its properties and preparation..... 13147
The Separation of Resin from Fatty Acids.—By E. TWITCHELL.—The analysis of soap containing resin.—Excellent method for its accomplishment..... 13154

V. ELECTRICITY.—Combined Dynamo and Engine.—Some recent examples of European practice, including a motor designed for use on a five-wire system of distribution.—3 illustrations..... 13143
Development of Electric Railways.—By EUGENE GRIFFIN.—A very important article upon the commercial development of electrical railways, with interesting historical documents..... 13140

VI. RAILROAD ENGINEERING.—The Los Angeles Cable Railway.—One of the great cable roads of the country described, with dimensions and data.—5 illustrations..... 13146

VII. GEOLOGY.—Coal.—Abstract of Prof. Jones' address to the Geological Section of the British Association..... 13158

VIII. MEDICINE AND HYGIENE.—The Use of Compressed Air in Conjunction with Medicinal Solutions in the Treatment of Nervous and Mental Affections.—By J. LEONARD CORNING.—The conclusion of this paper, describing the apparatus, with typical cases.—3 illustrations..... 13155
Lotions for baldness.—Formulæ for mixtures for the hair..... 13156

IX. METALLURGY.—Improved Process of Casting Steel Car Wheels.—An ingenious modification of the ordinary process of moulding car wheels.—2 illustrations..... 13146
Recovering Tin from Waste Tin Plate.—The removal of tin from tin scraps by treatment with caustic soda.—1 illustration.... 13151
Theory and Practice in Metallurgy.—By Prof. W. C. ROBERTS-AUSTEN.—A most able paper, treating of the last developments in metallurgical chemistry..... 13146

X. MINING ENGINEERING.—Moving Coal by Blowing.—A pneumatic apparatus for conveying small coal at mines.—1 illustration..... 13146

XI. MISCELLANEOUS.—Improved Blowpipe.—A blowpipe for use by the chemist and jeweler.—1 illustration..... 13151
Worms in Lead Pipes.—A possibility of damage to lead work by the larva of a wood worm..... 13151

XII. TECHNOLOGY.—Process of Making Caustic Alkali.—By FRANCIS ELLERSHAUSEN.—A novel method of preparing sodium hydroxide, with formula..... 13154
Soda Wood Pulp.—Results obtained in a Swedish works..... 13151
The Distillation of Molasses.—By Prof. T. P. HUTCHINSON.—A review of the commercial aspects of this industry as carried on in the South..... 13151
The Smoke Annihilator.—1 illustration..... 13150

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